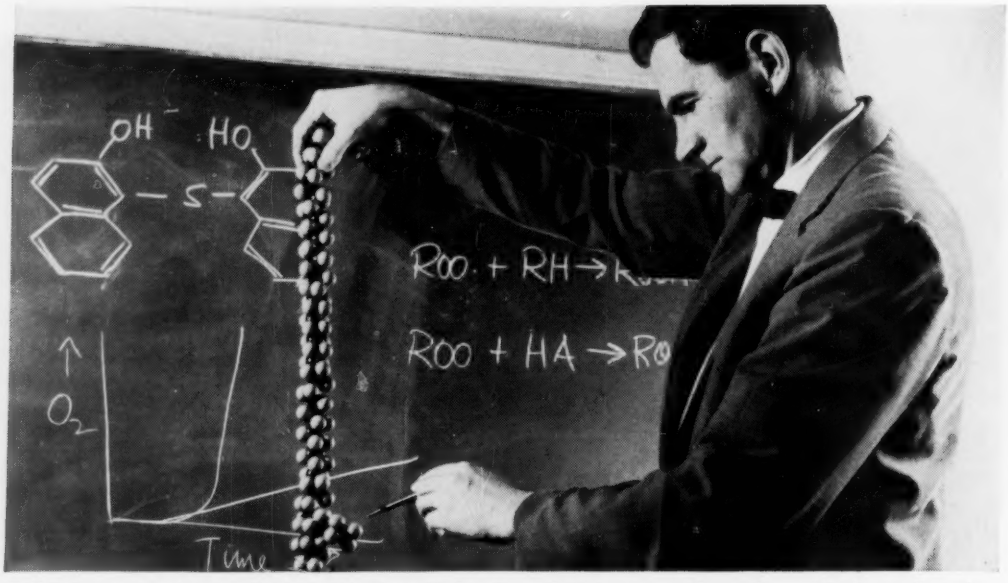
The SCIENTIFIC MONTHLY

UNI ITY
OF M GAN
AUG 2 19
ENGINEERING
LIBRARY

VOL. 85 NO. 3 SEPTEMBER 1957



Bell Laboratories chemist Field H. Winslow, Ph.D., Cornell University, with a scale model of a small section of a polyethylene molecule. Branch formation indicated by pencil is vulnerable to oxidation. Dr. Winslow and his associates worked out a simple way to protect long polyethylene molecules needed for durable cable sheathing.

THE DILEMMA OF GIANT MOLECULES

Solution: 2 plus 2 equals 5

Polyethylene is used to protect thousands of miles of telephone cables. It is tough, light and long lasting. Its strength lies in its giant molecules—a thousand times bigger, for example, than those of its brittle chemical cousin, paraffin wax.

But polyethylene has a powerful enemy: oxidation, energized by light and heat, shatters its huge molecules to pieces. This enemy had to be conquered if polyethylene was to meet the rigorous demands of cable sheathing. Paradoxically, it was done by making the whole better than the sum of its parts—just as though 2 plus 2 could be made to add up to 5.

To check the ravages of light, Bell Laboratories chemists devised the simple yet highly effective remedy of adding a tiny dose of carbon black. Then antioxidants, such as those commonly used to protect rubber, were added to check attack by heat. But here the chemists encountered a dilemma: although the carbon black protected against the effects of light, it critically weakened the effectiveness of the antioxidants.

To solve this dilemma, Bell Labs chemists developed entirely new types of antioxidants—compounds not weakened by carbon black but which, intriguingly, are very much more effective when carbon black is present. The new antioxidants, plus carbon black, in partnership, provide long-lasting cable sheath—another example of how research at Bell Telephone Laboratories works to improve telephone service.

BELL TELEPHONE LABORATORIES

WORLD CENTER OF COMMUNICATIONS RESEARCH AND DEVELOPMENT

UNIVERSITY OF MICHIGAN
AUG 2 1957
ENGINEERING LIBRARY

THE SCIENTIFIC MONTHLY

VOL. 85 SEPTEMBER 1957 NO. 3

World Population in Relation to Potential Food Supply . . . . . *Warren H. Leonard* 113

Training of a Scientist . . . . . *Van Cleve Morris* 126

IGY Rocket Program . . . *Subcommittee for IGY of the Technical Panel for Rocketry* 130

Sadi Carnot . . . . . *Milton Kerker* 143

American Medical Mission to the Soviet Union . . . . . *John R. Paul* 150

Book Reviews of *Physics for Everybody; Introducing Astronomy; Medicine in a Changing Society; The Classification of Lower Organisms; Sedimentary Rocks; Christian Theology and Natural Science; Disaster; Milton and Science; America's Natural Resources; Seitaro Tsuboi Commemorative Volume; Elements of Engineering Thermodynamics; Comfort for Survival; A Textbook of Sound; Human and Animal Ecology*; Books Reviewed in *Science*; New Books 157

Cover: Rare Photograph of Middle Ear Bones

[*Courtesy Myron R. Kirsch, 950 Fairbrook Lane, Santa Ana, California, see page 129*]

GRAHAM DUSHANE, *Editor*
CHARLOTTE V. MEETING, *Associate Editor*
JOSEPH TURNER, *Assistant Editor*

EDITORIAL BOARD

WALLACE R. BRODE
BENTLEY GLASS
KARL LARK-HOROVITZ
EDWIN M. LERNER
WILLIAM L. STRAUS, JR.
EDWARD L. TATUM

Advertising Representative: EARL J. SCHERAGO

THE SCIENTIFIC MONTHLY, established in 1872 as *The Popular Science Monthly*, has been an official publication of the American Association for the Advancement of Science since 1915. It is published for the Association at Business Press, Inc., Lancaster, Pa.

Copyright, 1957, by the American Association for the Advancement of Science. Entered at the Lancaster, Pa., Post Office as second class matter under the act of 3 March 1879.

All correspondence should be addressed to THE SCIENTIFIC MONTHLY, 1515 Massachusetts Ave., N.W., Washington 5, D. C. Manuscripts should be typed with double spacing and submitted in duplicate. The AAAS assumes no responsibility for the safety of manuscripts and photographs or for the statements and opinions expressed by contributors.

Change of address: Four weeks are required to effect a change of address. If possible, please furnish an address stencil label from a recent issue. Be sure to give both old and new addresses, including postal zone numbers, if any.

Annual subscriptions: $7.50, domestic and foreign. Single copies, 75¢. Special rates to members of the AAAS.

THE SCIENTIFIC MONTHLY is indexed in the *Reader's Guide to Periodical Literature*.

Effective 1 January 1958, THE SCIENTIFIC MONTHLY will be combined with SCIENCE, the weekly journal of the AAAS.

Science and Technology

All inquiries concerning items listed here should be addressed to The Scientific Monthly, *Room 740, 11 W. 42 St., New York 36, N.Y. Include the name(s) of the manufacturer(s) and the department number(s).*

Radar Restituter

Radar restituter automatically computes the errors that give rise to the distortions present in radar photography and produces a new photograph on which ground objects are accurately located. The chief distortions eliminated arise from the observation of slant distance rather than ground distance and from the motion of the radar. The corrected photographs are suitable for compilation of maps. (Fairchild Camera and Instrument Corp., Dept. M427)

X-ray Viewer

Readability of x-ray pictures is increased by a viewer through enhancement of contrast and through color TV techniques. Areas of equal optical contrast are displayed in the same color while variations in density are distinguished by variations in color. The image of the photograph to be viewed is converted to a sequence of electric signals by a cathode-ray, flying-spot scanner. The signal is amplified and subjected to electronic contrast enhancement. The amplified signal is next fed through a color monitor where the picture is reproduced in color. The image can also be converted from negative to positive by electronic means. (Philco Corp., Dept. M439)

Laboratory Safety

A 56-page booklet on laboratory safety contains descriptions of equipment designed for safe handling in the laboratory, as well as sections on accident prevention, first aid, fire prevention, and bibliographic references on laboratory safety. (Fisher Scientific, Dept. M446)

Potentiometric Recorder

A self-balancing potentiometric recorder measures current or voltage in 40 ranges. Nine chart speeds, from ⅓ to 12 in./min, are standard, with provision for optional 1-to-5 multiplication or 10-to-1 reduction. Eleven ranges from 1.25 to 1250 are selectably direct reading in millivolts, milliamperes, or microamperes. Higher voltage ranges are provided through a divider. Accuracy is 0.1 percent or 20 μv, whichever is greater, and speed is 1.8 sec full scale on standard instruments. Chart width is 250 mm. Chart motion at 20 ft/min is provided for scanning in either direction. (E. H. Sargent and Co., Dept. M459)

Gem Tester

Gem-testing set is based on the fact that neither index of refraction nor specific gravity separately will identify a gem but that together these properties will identify a gem with certainty. The set includes a "Refractoscope" used with six index-of-refraction liquids and a set of nine specific-gravity liquids. (R. P. Cargille Laboratories, Inc., Dept. M357)

Reactor

Training reactor designed to meet the needs of nuclear engineering curricula in college and university is described in a 16-page brochure. Information given includes specifications, a cutaway view of the reactor, and a typical layout for arrangement of facilities. (American-Standard Corp., Dept. M369)

Camera

Designed primarily for meteorological use, a new camera covers a 180-deg angle of view. The entire celestial dome and 360 deg of horizon are included in the image. The camera uses No. 120 roll film. Negative size is 2¼ by 2¼ in. Focal length is 16 mm. Shutter speeds are up to 1/200 sec. (Nikon Inc., Dept. M387)

Converter

Time-to-pulse-height converter is designed for measurement of time intervals in the range 250 μμsec to 1 μsec. The instrument requires that the time interval of interest be defined by an initial and a final pulse. Output is a pulse whose amplitude is proportional, within ± 1 percent, to the time interval being measured. Readout may be accomplished either by a multichannel pulse-height analyzer or by an oscilloscope. Resolution times of the order of 40 μμsec are said to have been achieved by the instrument. (El Dorado Electronics Co., Dept. M512)

Metal Detector

Magnetic or nonmagnetic metals are detected by a metal detector with an inspection aperture measuring 64 by 1⅛ in., through which the material to be checked passes. Sensitivity is adjustable for detection of particles as small as 0.039 in. in diameter. Distortion by metal of the high-frequency electromagnetic field that is set up in the aperture creates an electric signal, which is amplified to trigger an alarm. Strip material can be inspected at speeds of from 10 to 1000 ft/min. (Radio Corporation of America, Dept. M518)

Spectrometer

Mass spectrometer operates on the time-of-flight principle of mass separation. Resolving power is sufficient to separate adjacent mass peaks in the 200-atomic-mass-unit range. The complete spectrum is analyzed in about 15 μsec and displayed on a cathode-ray oscilloscope. The analysis is repeated at intervals of 500 μsec or less. One fixed setting of the instrument covers the entire mass range. Accessories allow the recording of two individually selected mass peaks and their ratio. Also available are devices for counting of individual ions with digital presentation of ratio in the ion-current range from 10^{-15} to less than 10^{-20} amp. The instrument is also suitable for molecular beam work. (Bendix Aviation Corp., Dept. M528)

Circuit Boards

Printed circuit boards of photosensitive glass will withstand a continuous operating temperature of 500°C. Since the etching ratio is 15 times higher than that of conventional glasses, small holes with close center-to-center distances can be produced. The boards are available in thicknesses from 0.05 to 0.235 in. and up to 12 by 18 in. in size. (Corning Glass Works, Dept. M410)

Neutron Detector

Thermal neutrons in the presence of high gamma flux can be measured with a new neutron detector, a boron polyester with ZnS(Ag) activator. Detection efficiency ranges up to 35 percent and can be further increased by the use of enriched boron-10. The detector is supplied in disks 1.2 mm thick and of various diameters. (Nuclear Enterprises, Ltd., Dept. M406)

Milliohmmeter

Resistances from 20 μohm to 1200 ohm may be measured by a new milliohmmeter manufactured by Electronic Instruments Ltd., of England. The instrument is line-operated, using a-c test currents at line frequency. Power dissipated in the test specimen is less than ⅛ w in the worst case. Accuracy is approximately ± 2 percent of full scale. A calibration circuit permits the accuracy to be checked. (Herman U. Sticht Co., Inc., Dept. M526)

Cathetometers

Coordinate cathetometers make both a horizontal and a vertical measurement in a vertical plane in one setting. The cathetometer consists of a microscope or telemicroscope mounted so that it can be moved on a vertical bar. This assembly in turn may be moved laterally on horizontal ways. Micrometer screws provide fine adjustment. Coordinate ranges from 2 by 2 in. to 42 by 42 in. are available. (Gaertner Scientific Corp., Dept. M516)

Computer Programmer

Programmer for six- and eight-channel oscillograph recording systems produces the following automatic sequence for analog computer readout: recorder is turned on; calibration signal voltages are fed to all channels; d-c levels of computer are read; computer output is recorded for predetermined chart length or as controlled by computer; recorder is turned off and programmer is reset. (Sanborn Co., Dept. M502)

Test Meter

Voltage standard and null meter can be used to provide reference voltages from 1 to 501 v with standard cell accuracy or to measure voltage over the same range. The instrument's chopper-stabilized circuit compares the output with an internal standard cell. As a power supply, the unit will furnish current up to 20 ma. Stability is ± 0.01 percent, accuracy ± 0.02 percent, line and load regulation 0.002 percent, ripple less than 100 μv, response time 0.2 msec, and output impedance less than 0.01 ohm. (Kin Tel, Dept. M542)

Timer

Nuclear-powered electric timer has a shelf and use life of more than 25 years. One model of the timer, 2½ in. in diameter and 1⅞ in. long, provides electric time delay ranging from several milliseconds to 40 hours with accuracy of ± 3 percent over the temperature range −65° to 165°F. Time delay may be initiated by snap-action switch, pull wire, or electric signal. Power is furnished by a nuclear battery made in current ratings from 50 to 5000 μμa and equilibrium voltages in the order of 10,000 v. (Universal Winding Co., Dept. M546)

Gamma Reference Standards

Cobalt-57, barium-133, cesium-137, manganese-54, sodium-22, and cobalt-60 sources are available as gamma reference standards. Each source is sealed in a cylindrical Lucite sample holder 5 in. long and ⅝ in. in diameter. The quantity of isotope has been adjusted to yield about 50,000 to 100,000 count/min above 20 kev with activity less than 0.1 μc. (Baird-Atomic Inc., Dept. M513)

Infrared Monochromator

Airborne infrared monochromator is designed to determine the absolute spectral distribution of radiation from airborne targets in the 1.5-to-25-μ region and to determine total radiation. Measurements are recorded on a two-channel recorder. Radiation collected by a Newtonian telescope optical system is reflected alternately to a total radiation detector and a monochromator. Thermistor bolometers are used as detecting elements. (Servo Corporation of America, Dept. M519)

Abrasion Tester

Rotary and reciprocating motions are combined in an abrasion tester that is designed for testing the durability of materials that are to be subjected to rubbing and twisting types of wear. Both the reciprocating table and the rotating head to which the sample is attached are equipped with ring clamps, which permit substitution of a variety of surfaces. Provision is made for wet-and-dry tests. (United States Testing Co., Inc., Dept. M520)

Wind Recorder

Wind-recording system incorporates a drag-free transducer based on the principle of light-beam chopping. Wind direction is sensed by a low-inertia potentiometer. Accuracy for wind speed is ± 4 percent of full scale and for wind direction, ± 3 percent. Switching is provided among four scales with ranges from 6 to 60 mi/hr. (Beckman and Whitley Inc., Dept. M525)

Densitometer

Integrating densitometer, for scanning paper electrophoretograms and chromatograms, furnishes two records. One is the curve of optical density, absorbance, or transmittance. The other is the integral of the first curve. The paper strip holder and scanning head will accept a wide variety of paper dimensions. (Matthew Laboratories, Dept. M515)

APPLICATION FOR HOTEL RESERVATIONS

124th AAAS MEETING

Indianapolis, December 26-30, 1957

The list of hotels and their rates and the reservation coupon below are for your convenience in making your hotel room reservation in Indianapolis. Please send your application, *not* to any hotel directly, but to the AAAS Housing Bureau in Indianapolis and thereby avoid delay and confusion. (Exception: Members of the American Astronomical Society who wish reservations at the Marott Hotel, 2625 North Meridian Street, are asked to correspond directly with that hotel.) The experienced Housing Bureau will make assignments promptly; a confirmation will be sent you in two weeks or less.

As in any city, single-bedded rooms may become scarce; double rooms for single occupancy cost more; for a lower rate, share a twin-bedded room with a colleague. Most hotels will place comfortable rollaway beds in rooms or suites at 2.50 to 3.00 per night. Mail your application *now* to secure your first choice of desired accommodations. All requests for reservations must give a definite date and estimated hour of arrival, and also probable date of departure.

AMERICAN ASSOCIATION FOR THE ADVANCEMENT OF SCIENCE

Rates for Rooms with Bath

All hotels have sessions in their public rooms. For a list of headquarters of each participating society and section, please see *Science,* July 19, or *The Scientific Monthly* for August.

Hotel	Single	Double Bed	Twin Bed	Suite
Antlers	$4.50–10.00	$7.00–12.00	$10.50–12.00	$14.50–19.50
Claypool	7.00–10.00	9.50–14.00	10.50–14.00	13.50–34.00
Continental	8.00–10.00	8.00–12.00	8.00–12.00	12.00–15.00
Marott	7.00–14.50	9.00–14.50	10.00–17.50	14.50 and up
Severin	6.00– 9.00	8.50–12.50	11.00–15.00	25.00
Sheraton-Lincoln	6.50–11.50	9.85–15.00	13.35–16.00	24.35 and up
Warren	6.50–10.50	8.50–12.50	12.00–13.00	25.00–35.00
Washington	5.50–10.00	7.00–11.00	11.50–16.00	18.00–45.00

---------- THIS IS YOUR HOUSING RESERVATION COUPON ----------

AAAS Housing Bureau
1201 Roosevelt Building
Indianapolis 4, Ind.

Date of Application .....

Please reserve the following accommodations for the 124th Meeting of the AAAS in Indianapolis, Dec. 26–30, 1957:

TYPE OF ACCOMMODATION DESIRED

Single Room ..... Desired Rate ..... Maximum Rate .....
Double-Bedded Room ... Desired Rate ..... Maximum Rate ..... Number in Party .....
Twin-Bedded Room .... Desired Rate ..... Maximum Rate .....
Suite ..... Desired Rate ..... Maximum Rate ..... Sharing this room will be:

(Attach list if this space is insufficient. The name and address of each person, including yourself, must be listed.)

.....

.....

First Choice Hotel ..... **Second Choice Hotel** ..... **Third Choice Hotel** .....

DATE OF ARRIVAL ..... DEPARTURE DATE .....
(These must be indicated—add approximate hour, a.m. or p.m.)

NAME .....
(Individual requesting reservation) (Please print or type)

ADDRESS .....
(Street) (City and Zone) (State)

Mail this now to the Housing Bureau. **Rooms will be assigned and confirmed in order of receipt of reservation**

THE
SCIENTIFIC MONTHLY

SEPTEMBER 1957

World Population in Relation to Potential Food Supply

WARREN H. LEONARD

Dr. Leonard received his training at Colorado State University, the University of Nebraska, and the University of Minnesota. In 1945–46 he served with the United States occupation forces in Tokyo as chief of the Agriculture Division, Natural Resources Section, and was primarily concerned with agricultural production to meet food requirements of the Japanese people. For this work he was decorated with the Legion of Merit in 1946. After 2 years as a member of the faculty of Colorado State University, he returned to Japan to serve again as chief of the Agriculture Division, this time in a civilian capacity. He is now professor of agronomy at Colorado State University and agronomist of the Colorado Agricultural Experiment Station. This article is adapted from a lecture that he delivered before the Institute of Biology, University of Wyoming, in July 1955.

HUNGER, starvation, and famine have repeatedly stalked mankind since the dawn of history. The so-called "race" between population and food supply was brought home to the present generation by the world food shortage that followed World War II in 1945.

It is often stated that more than one-half of the world population suffers from serious malnutrition. Because of the current accelerated rate of population growth, many writers take a pessimistic view of the ability of man to feed himself in the future. There is even concern in the United States that by 1975 food supplies will be inadequate to feed Americans on the present high-standard diet. Biologists will be directly or indirectly concerned with the problem at least for many years.

The problem of obtaining sufficient food for a population that continues to increase in a world of limited land area was raised by Thomas R. Malthus in 1798. He argued that man could increase his subsistence only in arithmetic progression, whereas his numbers tended to increase in geometric progression. Acre yields might be doubled once or even twice, but there is a limit beyond which increases are impossible. Malthus asserted that the history of mankind demonstrates that population always tends toward the limit set by subsistence. The population is contained within that limit by the operation of checks such as want, famine, pestilence, and early mortality (*1*).

The Malthusian doctrine has suffered many apparent setbacks since it was first propounded. Three developments, which were hardly foreseeable at the time, soon occurred: (i) changes in the agricultural system, (ii) introduction of chemical fertilizers, and (iii) the bringing of new regions into cultivation (*2*). Nothing more was heard of the food problem until Sir William Crookes delivered his famous address on "The wheat problem" in 1898. The problem was solved after 1900, largely through application of the new Mendelian genetics to the development of improved wheat

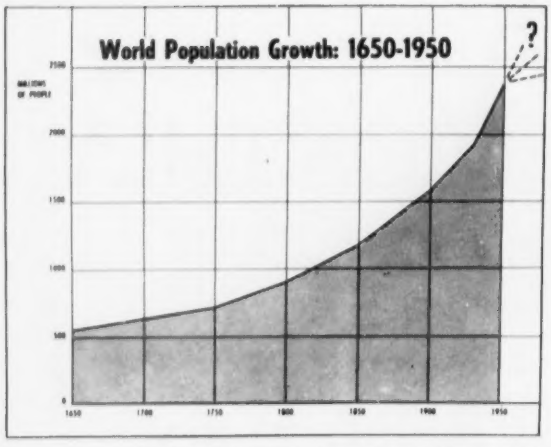


Fig. 1. Growth of world population from 1650 to 1950. [Population Reference Bureau]

varieties. Interest in the global food-supply problem again waned, except for a few years after World War I. The most recent food scare was brought on by dislocations in food production caused by World War II (*3, 4*).

World Population Problem

The present upsurge in population has raised some grave questions about how long the people of the world can be fed. The numbers eventually may be reduced by the Four Horsemen of the Apocalypse—famine, pestilence, war, and death—unless food production can keep pace with population growth.

Population growth. There is considerable guesswork in estimates of early world population. The population at the beginning of the Christian Era has been variously estimated as being between 210 and 250 million people (*5*). The estimated aggregate world population in A.D. 1000 was somewhere around 275 million, but it reached 518 million by 1650 (*6*). The United Nations' estimate of the world population in 1950 was 2406 million, but in 1956 it was reported as 2700 million (*7*).

Modern population trends stem from the 17th century, the period when the foundations of modern science were established. Up until 1650, the rate of world population increase was very slow. In no half-century prior to 1650 did the population increase by more than 10 percent. After that date, there was an upsurge at an accelerated rate. The world population more than quadrupled in the 300 years from 1650 to 1950 (Fig. 1). In fact, in the past century alone (1850–1950) it has more than doubled. The increase from 1900 to 1949 was 800 million people, or 52 percent. At this rate, another 1200 million will be added to the world population by A.D. 2000. Population in the United States has contributed to this growth, showing a rapid rate of increase in recent years. The population reached 170 million people in February 1957. In its most conservative estimate, the Bureau of the Census predicts a population of 206.9 million people in the United States in 1975. The highest estimate, based on continued 1954–55 fertility rates, is 228.5 million people (*8*). With the accelerated rates of population growth now apparent, it is easy to understand the alarm of many contemporary Malthusians (*9*).

The net excess of births over deaths determines the speed with which world population grows. Birth rates in the world as a whole have pressed toward 40 per 1000 of population, or 4 percent per year. It has been assumed until recently that high and fairly stable birth rates would continue to prevail (*6, 9*). There is credible evidence of a decline in birth rate only during and since the 19th century, in a few industrialized countries. High birth rates are now typical in underdeveloped countries of the world (*10*).

High death rates appear to explain the slow population growth prior to A.D. 1650. Mortality was high among infants, children, and youths. These deaths were caused by diseases, infanticide, famine, and wars. Advances in knowledge of medicine and sanitation since 1650 have contributed to markedly lower death rates, particularly during the past 100 years.

Population adjustments. Any change that tends to force the size of the population into conformity with food supplies can be termed a population adjustment. One set of factors—high birth rates and modern medicine—tends to adjust the population upward. Another set of factors—famine, war, and disease—adjusts it downward. Migration may result in a better distribution of the population in terms of food supply (*11*).

An uncontrolled birth rate adjusts the population upward. Thompson (*12*) states that, throughout human history, the birth rate has tended to approach the physiological maximum of about 45 to 50 per 1000 per year. This is about 3 times the rate required for a stable population when the death rate is subject to the control afforded by modern medicine. Introduction of some measure of modern medical facilities has contributed to acute population problems, particularly in Ceylon, Java, and Japan and in several other Asiatic countries.

Famine is an effective population control (Fig. 2). The birth rate generally drops under the stress of famine. Man multiplies rapidly when his food

supply is increased but dies when it fails. Asiatics have good reason to understand how famine holds the population in line with the food supply, for famines have been frequent in the Orient. One study revealed that there were 1929 famines in China between 108 B.C. and A.D. 1911 (*11*). An estimated 2 to 3 million farmers died of starvation in the Bengal famine of 1943 (*13*).

War has been another effective means for the adjustment of population to the food supply. It temporarily reduces populations, but in extreme cases entire peoples may be almost wholly destroyed. However, there are exceptions. World War II did not really reduce the population of Europe; between 1940 and 1950 the population increased from about 380 million to 393 million. The effects of war are so diverse that it is difficult to generalize about them satisfactorily.

Diseases such as smallpox, diphtheria, typhus, cholera, and malaria have preyed on man since before the dawn of history. They have taken heavy tolls. For example, about one-fourth of all Europeans died between 1347 and 1349, the years of the Black Death. Disease has been a constant check on population. Modern medicine tends to remove this check without a compensatory reduction in the birth rate, but finally disease is supplemented by starvation as an equally harsh adjuster (*14*).

Migration may be an adjustment of population to food supply. When a population outgrows its food resources, it may seek to migrate to other areas where food is more plentiful. This often occurred in China. It is less expensive to transport a man to areas where there is surplus food than to ship his food supply to him for a lifetime. However, migration is only a temporary expedient insofar as the world population problem is concerned (*14*).

Present population problem. There is now an unprecedented upsurge in world population, at a rate of 1.5 percent, or 40 million per year (*7*). Continued population growth at this rate would soon blanket the surface of the earth with people. The ancient reproductive pattern was based on a life-expectancy of 25 to 28 years. This expectancy has been greatly modified by modern medicine, together with scientific public health control. For example, since the introduction of such practices, Japan has approximately doubled the span of life-expectancy, to about 60 years. The combination of a low death rate with a constantly high birth rate cannot long exist. Either the birth rate must be reduced to approximate the death rate or the population will be reduced to conform with the available food supply by the ancient population adjusters. These adjusters are now in operation in

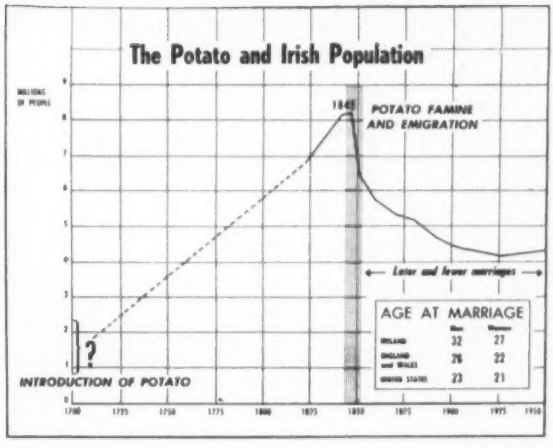


Fig. 2. Effects of potato famine on population of Ireland. ("Age at marriage" figures are for about 1954–55.) [Population Reference Bureau]

many parts of the world, where half of the children die before they reach the age of 13 (*15*). India affords a good example of such a condition. Forbes (*13*) states that a low food-to-population ratio for most people tends toward a stable situation of permanent poverty and early death.

It is paradoxical that the application of modern medicine and methods of sanitation has lowered death rates in underdeveloped areas but has failed to lower birth rates. The Point Four program for increasing food production in overpopulated areas has been offset to a considerable extent by the spread of modern medicine in such areas. Consequently, the food-population balance has been upset in these densely populated areas. Recent surveys of the Pakistan problem of food-land-people reveal that a 20-percent increase in food production since World War II has been canceled by an even greater increase in population. Today, the food available per person is 10 percent less than it was 15 years ago (*16*). Puerto Rico affords another example of the population paradox brought on by lowered death rates through the application of the vital tools of public health, medicine, and sanitation without parallel attempts to lower the birth rate. As a result of American good intentions, thousands of the beneficiaries of these humanitarian measures live under the shadow of malnutrition (*17*). The United States Army instituted nation-wide control of communicable diseases in Occupied Japan after World War II; this further reduced an already low Japanese death rate to approximately that of advanced Occidental nations like the United States, but Japan still maintained its Oriental birth rate. However, the

birth rate in Japan has fallen markedly since 1947, largely because of legalized abortion, instituted by the Japanese themselves. Continued high birth rates in underdeveloped countries may create social problems conducive to the development of Communism, unless drastic measures are taken to curb the population increase.

World Food Problem

World food supplies can be increased by higher production on present agricultural land, by the reclamation of new land for food production, and by the discovery of improved agricultural practices through scientific research. Aside from conventional agricultural means, food supplies may be further increased by the synthesis of foods as well as by the culture of certain lower plant forms, such as yeast and chlorella.

Land use. Less than 10 percent of the total world land area is now cultivated. Cressey (*18*) estimates that 8 percent, or 2838 million acres, is arable land, fallow land, and orchards. Another 5402 million acres, or 15 percent, are used for grazing. Some 75 percent of the world land area now produces little or no food.

Little cultivated land has been added to the world total since 1930. In fact, in many countries the area of cultivated land is on the decrease. Land is being taken for a variety of uses other than production of food—for cities, airports, roads, military grounds, and industrial plants and for numerous other needs (*2*). It is paradoxical that, for such purposes, it is first-class agricultural land that is generally selected. Other farm lands throughout the world continue to be abandoned because of improper irrigation, water erosion, and soil blowing. The total amount of land annually taken out of food production is appreciable. Loss of good agricultural land has been partly offset by bringing new land under cultivation, but the new land is generally less productive than the lost land.

The late R. M. Salter (*19, 20*) explored the possibilities of bringing new land under cultivation for the production of additional food. About 48 percent of the total land area consists of snow, ice, tundra, mountains, and deserts and has no agricultural value. The other 52 percent of the land area is occupied by Chernozem, Chestnut, Gray Forest, Podzol, and Red soils, in which there may be possibilities for agricultural expansion. Many of these soils are unsuitable for cultivation because they are too sandy, too stony, too salty, too hilly, or too wet. An estimated 20 percent, or 1000 million acres, of the Red soils of the tropics might be used in the calculated world soil potentialities. Another 10 percent of the Podzol soils of the Northern Hemisphere, or about 300 million acres, might be brought under cultivation. The cost of reclamation for both types would be high. Most of these soils would need heavy fertilization to maintain continued productivity. In many cases, this land also would have to be drained, irrigated, or terraced.

World food requirements. Late in 1945, the Food and Agriculture Organization (FAO) of the United Nations was formed, with the mission of making "freedom from want" a world-wide reality. As a result of the first FAO world food survey, published in 1946, food targets were set up for 1960, based on an assumed population increase of 25 percent above that of 1935 (*21*). To feed this enlarged population, as well as to raise the consumption of the world population to a 2600-calorie level, with improved diets, the survey estimates, will require the following increases in food production beyond the pre-World War II level: cereals, 21 percent; roots and tubers, 27 percent; sugar, 12 percent; fats and oils, 34 percent; pulses and nuts, 80 percent; fruits and vegetables, 163 percent; meat, 46 percent; and milk, 100 percent.

Despite this program, a second world food survey, published in 1952, indicates that food production only overtook the increase in population 5 years after World War II was over (*22*). Although food production was increased materially in this period, the average food supply per person over large areas of the world was still lower than it was before the war (1934–38). It was estimated that a well-balanced increase of 1 to 2 percent per annum in world production of basic food in excess of population growth is the minimum necessary to achieve some improvement in nutritional standards. With tentative estimates included for Communist-bloc countries, world food production in 1954 was estimated to be about 30 percent greater than in 1946–47 and about 20 percent greater than in 1934–38. The increase in food production, exclusive of Communist countries, has slightly outweighed the growth in population since before World War II (*23*). The tenuous success of this all-out effort to increase world food production is largely due to the intensive work of FAO and of Point Four, the Colombo Plan, and other programs.

Salter (*20*) estimated the world food production potential for 1960 on the basis of (i) possible increases from present farm land and (ii) possible increases from additional new land brought under cultivation (about 50 percent of present acreage). His world estimates for increases from present cropland are based on a 20-percent increase attainable in the United States from soil groups

similar to those in other countries, with adjustments made for different cultural practices in those countries. On the basis of these estimates, world food needs for sugar, starchy roots, and essentially for the cereals could be met, by 1960, on present cropland. Production of all other classes of food—fats and oils, pulses, fruits, vegetables, meat, and milk—would fall short of the need. Production from an estimated 1300 million acres of new land, together with that from present cropland, would more than meet world food needs by 1960, except for meat, pulses, and nuts. Production of cereals, starch roots, sugar, and fats and oils might well be far in excess of the amounts needed.

Some comments are made on the Salter estimates by Black and Kiefer (*24*). On the assumption that the population will continue to increase at the present rate after 1960, they estimate that population growth after 1980 will be possible only if there is a reduction of the per capita consumption of milk and meat, with more and more of the diet consisting of cereals, roots, tubers, sugar, and vegetable oils. Even with a shift in diet to cereals, roots, and tubers, the food supply would reach its limit within 75 years. The Salter estimates of food production potential may be doubled by those who consider them too conservative. However, the result would be the same, except that it would be deferred.

In spite of current food surpluses, there is concern in the United States about how to achieve food production that will be adequate to maintain the present diet for the anticipated population of 1975. A number of studies have shown that about 100 million more acres of cropland, or its equivalent, would be needed if all the additional production had to come from new land. Recent trends in land development indicate that the total area of cropland may reach 508 million acres by 1975—an increase of 6 percent, or of 30 million acres of new land over the 478 million acres available in 1950 (*25*). Most of the new land will have to be drained, cleared, or irrigated before it can be cropped. The additional production required must come largely from increased yields on present farm land (*26*).

Food composition. In nations where population presses on the food supply, most of the food, in terms of calories, comes directly from the cereal grains or other plant products. For example, in China, about 90 percent of the arable land is devoted to the production of crops for direct human consumption. Cereal grains are an inexpensive source of calories in terms of price or labor costs of production. One acre of rice in Japan will produce as many food calories for direct food consumption as will 5 or 6 acres of crops converted to animal products for food. Consequently, production of animals for food is economical only in lands where crop production is impossible.

The cereal grains are by far the most important food crop in the world. Bennett (*3*) has estimated that the cereal-potato group of crops accounted for 75 percent of the world "disappearance" of food calories in the period between 1933 and 1938. Potatoes could hardly have contributed more than 5 percent of the total number of calories. A high percentage of cereal-potato calories consumed directly as human food indicates a low dietary standard. As an average for all nations in Asia (except Japan), 80 to 90 percent of the calories in the diet come from the cereal-potato group. The Soviet Union also falls wholly within this category. In advanced Occidental countries, only 30 to 40 percent of the food calories come directly from the cereal-potato group—for example, in the United States, the United Kingdom, Switzerland, Sweden, Canada, Australia, and New Zealand. National diets composed of 70 percent or more of cereal-potato calories are likely to be qualitatively inadequate to the point where the human organism is damaged to some degree or other. These diets are deficient in animal products—proteins, vitamins, and minerals. Probably three-fourths of the world population subsists on diets qualitatively deficient in these items.

In terms of calories, there is a great waste of food resources when animals consume food that might be eaten directly by man. Maynard (*27*) estimates that about 20 percent of the gross energy (calories) fed to a pig (the most efficient converter among farm animals) is returned in products that can be eaten by man. The conversion figures for other animals are lower. However, ruminants consume roughage that man is unable to digest. These facts explain the presence of the small animal industry in countries where there is a struggle to obtain enough food for human beings.

Role of Agriculture in Food Production

Civilized nations depend on agriculture for food production. Some of the factors concerned with agriculture's success or failure in this role are noteworthy.

Agricultural resources. The soil is the critical resource for food production, but soil productivity actually is on the decline in large parts of the world. High yields of food crops per acre accelerate depletion of soil nutrients. Already the heavy drain of increased yields from hybrid corn has begun to show its effects in the highly fertile corn belt of

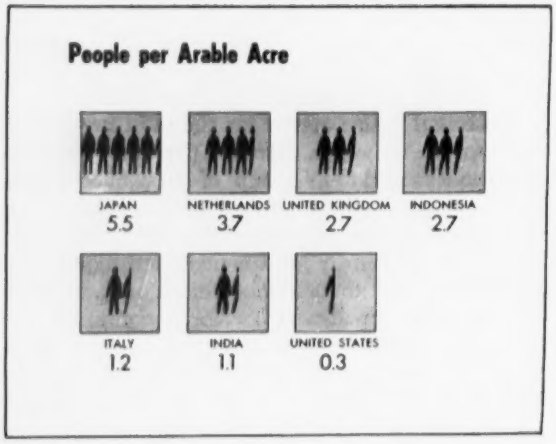


Fig. 3. Number of people per arable acre in various countries. [Population Reference Bureau]

the United States, where nitrogen, phosphorus, and potash deficiencies are more common than they were a few years ago (*28*). In many countries, heavy losses of fertile topsoil through erosion occur every year on land planted to row crops. Crop yields from irrigated lands are on the decrease in nearly all countries in the arid or semiarid zones. Large acreages of once-productive land have deteriorated to the point where much of it has been taken out of cultivation. The immediate causes are water-logging and soil salinity, resulting from improper or ineffective drainage practices. In the decade between 1929 and 1939, more than 1 million acres of irrigated land in the United States were abandoned because of excess salts (*29*). Some 20,000 to 30,000 acres of irrigated land are lost annually in the Punjab of Pakistan through land deterioration (*30*). Food production in the years ahead may depend on soil management for the maintenance of productivity, particularly as soils become older agriculturally.

Water is another critical agricultural resource of prime importance, particularly in dry climates (*31*). It is estimated that production increases of 100 to 150 percent may be obtained through the application of irrigation water to nonirrigated croplands in the western United States (*32*). There is considerably more land suitable for irrigation than there is water to irrigate it. Cities are now in direct competition with agriculture for the available water supplies. The limited amounts of irrigation water available for food crops must be used more and more efficiently in the future, in all countries.

Agricultural patterns. Farms of densely populated countries tend to be small in size, intensively worked, and planted almost entirely to food crops (Fig. 3). Japan affords a good example of intensive agriculture in an overpopulated country. The average Japanese farm is only about 2.5 acres in size, and it is usually made up of several noncontiguous units. The small-scale farming resembles gardening more than it does farming as practiced in the United States. Most of the work on Japanese farms is accomplished by hand labor, with primitive tools, but these tools are well suited to the conditions found there. Production per acre of land is extremely high, but the production per man is low. Many fields in Japan are made to produce two or more crops a year through the widespread practice of multiple cropping. Since the soils of Japan are naturally infertile, heavy fertilization is required for high yields. The fertilizers used are "night soil," green manures, barnyard manure, compost, and commercial fertilizers. Another feature of Japanese agriculture is the emphasis on production of food (particularly rice) for direct human consumption. Probably 80 to 85 percent of the farm acreage is planted to rice, barley, wheat, sweetpotatoes, and white potatoes. Livestock is of minor importance except for draft purposes.

As population pressure increases in a country, there is a trend toward the production of crops, particularly the cereals, for direct human consumption, because more food calories for human beings per unit area of land can be produced directly from crops than from feeding crops to livestock for the production of animal foods. Crop production is sometimes precarious because of its dependence on weather or other uncontrollable conditions. Such factors as drouth, severe storms, insect pests, or plant disease epidemics may cause serious shortage of food, or even famines. Livestock is a safety factor. Farm animals are an effective means for the condensation, as well as the storage, of surplus feed in periods of abundance. The number of meat animals then increases. A food reserve is built up which can be drawn on for meat in periods of food shortage. Thus, farm animals are a reserve food supply (*33*).

Methods for Increasing Food Production

There are numerous means by which world food production can be increased to meet future population needs. Less than one-fourth of the farmers of the world have begun to apply the techniques of modern science (*34*). It has been suggested that the yields from presently cultivated land can be increased from 20 to 50 percent on the basis of the best current farm practices, while about 50 percent more land can be economically brought under cultivation (*18, 19, 35*). Although this is still some-

what speculative, there are also possibilities for synthetic or industrial food production.

It is generally agreed that a large opportunity for increased food production lies in the application of improved practices to land already in crops. Food production in the United States increased about 40 percent from the 1935–39 period to 1945, mainly as a result of increased yields per acre. This feat was accomplished through improved varieties, greater use of chemical fertilizers, more effective chemical sprays for pests, more efficient farm implements, and many other means (*36*). Agricultural experts recognize that improved practices could be more widely used in the United States than they are today. R. M. Salter concluded that present agricultural production could be increased 60 to 75 percent if the best known practices were put into use on all farms (*19*). This is an ideal that can never be fully achieved. Maynard (*37*) states that one-half of this increase may be a more likely achievement during the next 25 years. However, it is a well-known fact that the best farmers obtain more than twice the crop yields obtained by the average farmer. Although the national average corn yield is less than 40 bushels per acre, more and more farmers each year produce 100 bushels per acre. Estimates indicate that agricultural requirements in the United States by 1975 can be met through improved technology based on information already available (*38*).

A shift from nonfood to food crops is a more effective means of increasing food supply than are attempts to increase crop production per unit area. For example, with the development of synthetic fibers, the cotton lands of the southern states are a potential source of food crops in case of dire food shortages. The average annual acreage of cotton harvested during the period from 1943 to 1952 was 21,823,000 acres. Owing to food shortages in Japan during and after World War II, the land area planted to mulberry trees for silkworm feed declined to only 30 to 35 percent of the acreage in these trees during the period from 1935 to 1940. Almost a million acres of such land were replanted with food crops (*39*). Similar shifts are possible in other countries when the need for food becomes critical.

It is much easier to suggest means by which food production can be increased than it is actually to produce the extra food. In terms of efficiency, there is a low level of food production in the world in general. High-level agricultural production depends on education, research, industry, and capital. The problem is made more difficult because many people of the world are bound by custom, tradition, myth, superstition, or religion. Many are reluctant to believe that plant diseases can be controlled by development of resistant varieties or by seed treatment. India has about twice as many cattle as does the United States, but religious beliefs permit only a low economic return from them. Cultural methods in many overpopulated countries are still primitive.

Research has made important contributions to increased production in the past, but it promises to play an even more important role in the future. Some selected results of research will be described to indicate the prospects for higher food production in the years ahead. Widespread use of improved practices based on research would go far toward fulfillment of present-day world food requirements.

Food Crop Production Potentials

As has already been indicated, a large percentage of the people of the world subsist on the cereal grains. Consequently, methods to increase the yields of these crops become very important. Increased crop production may be obtained by crop improvement, more effective cultural methods, increased soil fertility, and better pest control.

Crop improvement. Through the application of modern genetics, crop varieties are being bred to meet specific requirements, such as adaptation, high yields, improved quality, and disease resistance. Genetic effects frequently are confounded with effects of concurrent changes in cultural or other production practices.

Rice is the most important single food crop, and about half of the world population depends on this cereal, in whole or in part, for sustenance. The highest average rice yields in monsoon Asia are obtained in Japan, largely as a result of breeding improved varieties, together with the use of better cultural, fertilizer, and irrigation practices. Rice yields per acre were increased 71 percent in Japan between 1882 and 1942 (*40*). Rice yields per unit area in Japan are about twice as high as those in China or Malaya but between 3 and 4 times as high as those in India, Indo-China, Burma, and the Philippines. There is an excellent opportunity to increase acre yields by 15 to 20 percent in southeast Asia by application of methods used in Japan (*22*). For example, some recent rice-improvement work by Americans in Thailand indicates that nine selections under test outyielded local standard varieties by 30 to 78 percent (*41*).

Wheat is second among the great cereals. About 70 percent more wheat is grown in the United States than was grown 50 years ago, but the increase is largely due to cultivation of more acres.

A yield increase of 2.1 bushels per acre was obtained on the basis of two 10-year periods that ended in 1895 and 1945, respectively. This gain was largely due to the introduction of rust-resistant varieties as well as to the development of early drouth-resistant varieties that permitted the extension of wheat culture into the drier western states. Yields were maintained in spite of the large amount of less productive land brought under cultivation. Wheat yields in Japan were increased 140 percent between 1882 and 1942, largely through the use of improved varieties, together with commercial fertilizers (*42*).

The story of hybrid corn in the United States is one of the bright spots in the application of basic science to practical problems. Approximately 90.8 percent of the American corn acreage in 1956 was planted to hybrids, which generally outyield the old open-pollinated varieties by at least 30 percent (*43*). Quisenberry (*42*) attributed an average increase in annual yield of 13.4 bushels an acre to the use of hybrid corn varieties in the period from 1941 to 1946. The 1946 corn crop was 217 million bushels larger than the one produced in 1920, while it was grown on 10 million less acres. Hybrid corn trials in 14 European countries in 1951 and 1952 indicated that hybrids outyielded the best local open-pollinated varieties by 50 percent. In spite of this fact, hybrids are grown on only 6 percent of the corn acreage in Europe (*30*).

Sorghum is an important grain crop for human food in many parts of Africa and Asia. Sorghum breeding has made remarkable strides in the United States since 1930. New double-dwarf grain sorghums, 36 to 42 inches tall, have been tailor-made by plant breeders to make them suitable for combine harvest (*44*). The old standard varieties often were 72 to 96 inches tall. Since the new double-dwarf varieties have approximately the same leaf area as comparable standard types, they yield about the same amount of grain. Hybrid sorghums are about to go into commercial production. They were made possible through the application of cytoplasmic male sterility. Some tests indicate that hybrids will yield from 27 to 44 percent more grain than present varieties. Yellow endosperm varieties were introduced from Nigeria in 1952. The yellow pigment contains vitamin A similar to that in yellow corn (*45*). Pound for pound, yellow-grain sorghums promise to have about the same feed value as yellow corn.

Similar improved yields could be cited for many other food crops. Yields have been increased in the United States through the production of improved varieties of oats, barley, potatoes, sugar beets, sugar cane, and many other crops used for food or feed. Development of disease-resistant varieties has been an important factor in all cases. Tetraploid rye has been released for farm production in Sweden (*46*). A triploid sugar-beet variety developed in Japan now is being released to growers. It has outyielded the parent diploid variety by 10 to 15 percent (*47*).

Mechanization. Improved farm machinery has revolutionized American agriculture since 1900, particularly since about 1940. Research has played an important role in this advancement. The tractor has all but replaced the horse for farm work, and many acres formerly planted to feed crops for horses or mules used for farm power have been released for food production purposes. For the most part, mechanization has increased the efficiency of manpower rather than the production per acre. In 1900 each American farm worker produced enough agricultural products for himself and six others, whereas today each worker feeds 19 others besides himself (*48*). It should be emphasized that timeliness of cultural operations afforded by mechanization may be an important factor in high crop yields. Mechanization has spread because of large land areas, high-priced labor, and the availability of cheap fuel for tractors. It has been applied particularly to the cultivation of small grains, corn, and sugar beets.

In overpopulated countries, such as many in Asia, increased mechanization would in most cases be a mistake. These countries have a surplus of cheap manpower, require maximum efficiency in food production per unit area of land rather than efficient use of manpower, and generally lack the implements or fuel for mechanization. Replacement of such manpower by machines would create a serious social problem through unemployment. Usually more food per unit area can be produced by hand methods than by machine methods. However, improved hand tools or animal-drawn implements would undoubtedly aid in the attainment of higher food crop production in overpopulated countries.

Fertilizers. Marked increases in yields have been obtained by application of fertilizers to soils deficient in nitrogen, phosphorus, and potash. Large amounts of lime also are used to correct for soil acidity. It is conservatively estimated by FAO that a 30-percent increase in crop yields around the world could be obtained by an optimum use of fertilizers. World consumption of nitrogen, phosphorus, and potash fertilizers in terms of nutrients consumed in 1953–54 was about 18.5 million short tons, a third of which was used in the United States. It has been estimated that the consumption of plant nutrients in this country alone will range between 10 and 14 million tons by 1975 (*49*).

Minor or trace elements have become more and

more important. They include copper, zinc, manganese, boron, iron, molybdenum, magnesium, and sulfur. For example, the application of molybdenum at the rate of an ounce or so per acre, in New Zealand, has given good increases in yield.

As the world demands for fertilizers increase, the problem of supply of high-grade raw materials becomes more difficult in many instances. For example, the general shortage of elemental sulfur has necessitated the development of phosphatic fertilizers that do not require sulfur, or only in small amounts. Some of the new products developed through research are fused tricalcium phosphate, calcium metaphosphate, and rhenania phosphate (*50*).

Improvements in cultural practices. Research in soils has contributed materially to the maintenance of, or even increase in, soil productivity. Soil conservation practices have reduced soil erosion as well as other soil depletion processes. Large acreages of hilly lands are now farmed on the contour, terraced, or strip-cropped. Stubble-mulch tillage, where crop debris is kept on the soil surface, is a recent practice in erosion control. Cover crops or sod crops also reduce erosion. Some livestock farmers have returned their cultivated lands to pasture or hay crops (*51*). Soil fertility has been improved by the use of green manure crops, rotations, and chemical fertilizers. These practices have all contributed to higher crop yields. Recent experiments on corn culture in the southeastern states, under ordinary farm conditions, indicate that corn production can be more than doubled by a combination of heavy nitrogen fertilization, use of adapted hybrids, and growing of more plants per acre (*19*).

There are opportunities for producing more food on irrigated lands in the western United States through optimum combinations of irrigation, fertilizer application, and plant spacing to obtain the highest yields. In an experiment in Utah, sugarbeet yields as high as 34 tons per acre were obtained by such practices in an area where the average farm yields were 13 tons per acre (*50*). Similar results were obtained with grain sorghums in New Mexico in 1951. The average yield of grain sorghums for a previous 6-year period was 27 bushels per acre. The highest yield, of 102 bushels per acre, was obtained from a combination of 240 pounds of nitrogen, 80 pounds of phosphorus, spacing of plants 4 inches apart in 36-inch rows, and eight irrigations (*52*).

There are almost 1000 million acres of permanent grasslands in the United States, most of which are unimproved. Experiments, together with farm experience, indicate that production from much of this land could be doubled or trebled by fertilization, reseeding to adapted grasses and legumes, and management practices to assure maximum production (*26*).

Plant protection. Research has made marked progress in a continuous war on diseases, insects, and other pests that attack food crops.

Plant diseases have always posed a threat to the food crops. The potato blight (*Phytophthora infestans*), probably introduced into Ireland from America, caused the terrible famine of the 1840's. The annual losses of food crops from plant diseases are expressed in millions of dollars. Diseases are on the increase because modern transport is so widespread that they are carried quickly from one country to another. One of the best ways to deal with a disease is to select or breed crop varieties resistant to it. Wheat rust affords an example of the complications that occur as a result of new physiological forms that arise as mutations. Wheat production in the Western Hemisphere is now threatened by stem rust Race 15B, one of the most destructive diseases on record. None of the commercial varieties in this hemisphere carry resistance to the disease (*41*). New fungicides in the form of sprays or dusts have done much to control diseases on susceptible crops.

Insects cause serious losses in yields of food crops as well as considerable destruction of food products in storage. For many years, insect losses have been estimated at 10 percent of all agricultural production. Decker (*53*), on the basis of new evidence, hazards a guess that insect losses approach or even exceed 20 percent. A number of highly effective new insecticides have been developed during the past 10 or 12 years. These include the chlorinated hydrocarbons such as DDT, benzene hexachloride, aldrin, dieldrin, and heptachlor. New organic phosphate insecticides include parathion, TEPP, and malathion. These new chemicals now contribute markedly to higher crop yields in the United States by reduction of insect damage. For example, potato yields were increased 48 percent in an experiment in Maine in 1945 by the control of aphids through the addition of DDT to a fungicide (*42*). Since 1946, DDT has been used extensively for this purpose.

Many broad-leaved weeds in cereals or grasses can be destroyed at an early stage by certain selective chemical sprays. Those of the hormone type, such as 2,4-D, are widely used. An estimated 100 million acres of crops were sprayed with selective weed killers in 1952, chiefly in North America, the United Kingdom, and northwestern Europe (*2*). Several new compounds appear to have selective herbicidal qualities against some species of grass weeds that grow in broad-leaved crops—for example, IPC (o-isopropyl-n-phenyl carbamate),

Chloro-IPC, and Na-TCA (sodium trichloracetate) (*54*). Large acreages of Texas brushland have been converted into more productive grasslands by airplane application of 2,4,5-T to destroy mesquite.

Animal Production for Food Products

Domestic animals are an important source of human food such as meat, dairy products, and eggs. Such products are valuable as supplements to vegetable diets on account of the high content of protein, vitamins, and minerals.

Animal breeders, through application of Mendelian genetics, have bred better domestic animals. Artificial insemination has enabled animal breeders to multiply many times the effectiveness of superior sires. The phenomenon of hybrid vigor is being exploited in the production of hybrid chickens, pigs, sheep, and cattle.

Farm animals today are more efficient as contributors to the food supply of man than was the case 10 to 15 years ago because of application of the results of nutrition research. Moreover, animals are able to draw more and more on feed resources unsuitable for direct use by man. Animal products have a special importance in supplying nutrients that are otherwise likely to be deficient, particularly in cereal diets, on which most of the world population subsists (*27, 37*).

With respect to hogs, or poultry, protein nutrition depends on the kinds and amounts of amino acids supplied. Studies of amino acid requirements have resulted in feeding practices that have effected more economical production. The discovery of vitamin B_{12} as a growth factor for pigs and chickens has resulted in a replacement of animal protein feeds by vegetable protein sources plus vitamin B_{12}, with a more economic use of feed. Antibiotics fed to these animals in small amounts have been found to promote growth. By their use, rates of gains in pigs have increased by 10 to 20 percent and in chickens, by 5 to 10 percent, with a decrease in the amount of feed required (*27, 37*).

Ruminants such as cattle, sheep, and goats are able to utilize many coarse feeds that human beings are unable to digest. Experiments have shown that sheep can build body protein with urea as a sole source of nitrogen. Urea can replace up to 40 percent of the protein in the feed of ruminants without loss of production. This newly developed food source may prove to be revolutionary in tropical countries, where herbaceous matter is abundant but proteins scarce. It might make possible the production of meat, milk, and fat for protective human foods in these areas. Urea is a nonprotein nitrogen compound manufactured by the chemical industry (*55*).

Marked progress has been made throughout the world in the control of serious animal diseases such as the foot-and-mouth disease, rinderpest, brucellosis, tuberculosis, Q-fever, rabies, and anthrax (*56*). Effective control measures also have been developed for insects that are harmful to domestic animals.

Fish as Food Source

Fish are an important source of food in many countries. It is estimated by FAO that about 25 million metric tons of fish are produced annually. About two-thirds of these fish are available for human consumption, while 40 percent actually are edible. Although fish add little to the total world food supply, they are important on account of the high quality of the protein furnished. Maynard (*37*) estimated that fish supply only an average of 10 calories and 1.3 grams of protein per capita per day for the world population. Fish are important as food for people who live near the sources of supply. FAO estimates that fish production could be doubled without serious risk to future fish resources.

Cultivation of fish in fresh or in brackish waters has been undertaken in some countries. Fish ponds were started long ago in China. As a side line, the Japanese started fish culture in rice paddies about 100 years ago to furnish a protein supplement for their heavy rice diet. About 2.6 million pounds of carp were produced in 1952 in approximately 21,000 acres of rice paddies (*57*). Fish culture more recently has spread to several other countries in the Far East (*58*).

Industrial Development of Foods

Industry has played an important role in agricultural developments which have increased food production. As I have already indicated, it has developed efficient chemical fertilizers, designed improved farm machinery, and produced new chemicals for disease, insect, and weed control. Industry is essential to efficient agriculture. It has also developed synthetic food materials.

Synthetic food materials. Marked progress has been made in the synthetic production of fats, vitamins, and amino acids. Synthetic fats have been produced from coal hydrocarbon residues in Germany. Vitamins now produced synthetically by chemical industries include vitamins A, B (thiamine), B_2 (riboflavin), and C (ascorbic acid), choline, and B_{12}. Synthetic amino acids now man-

ufactured include methionine, lysine, and others (*55*). The food supplies of many peoples in the world are deficient in some of these nutrients. In overpopulated nations, it may be necessary to continue the present direct production of food crops in order to obtain the maximum number of calories per unit area of land. By supplementing the diets in these areas with the vitamins and amino acids that are now deficient, it may be possible to reduce malnutrition. Lysine is the amino acid most likely to be deficient in the diets of a large portion of the world's population, because it is deficient in the cereal grains. As one step, the development of processed rice, to enrich diets composed predominantly of rice with vitamins and minerals ordinarily removed in the bran, is already under way in many Asiatic countries (*37*).

There are possibilities for large-scale conversion of inedible plant materials into useful livestock feeds or even into human food. The vast forest resources are a source of such materials, particularly sawdust and other wood wastes. Maynard (*37*) states that, in World War I in both Germany and Scandinavia, wood and various other cellulose materials were hydrolyzed to lower carbohydrates, which were used as cattle feed. In World War II the process was extended to provide wood sugar, which was used directly as human food. These processes proved to be feasible as emergency measures. Witt (*55*) has suggested that some of the wood wastes and agricultural residues possibly could be made into delignified feed for ruminants, through fungal metabolism. He estimated that from 5 to 10 percent of the annual American farm and forest waste is potentially convertible into 14.9 million tons of total additional feedstuffs for ruminants. These feedstuffs would include 2 percent urea, to provide for one-third of the protein requirement for these animals. In comparison, the commercial feeds consumed in 1951 amounted to about 18.8 million tons.

Lower plant forms as food. Certain yeasts were cultivated by the Germans during World War I, by the use of sugar and synthetic nitrogen compounds in the form of ammonia or nitrates, as food. The yeasts converted these materials into edible protein for animals and man. Yeast food may be produced from wood sugar as well as from various carbohydrate waste materials. Yeasts are from 15 to 30 percent efficient in the conversion of gross energy to edible foods. On a dry-matter basis, yeast contains approximately 50 percent of protein, which is of high biological value. Yeasts are also rich as a source of vitamins (*37*). Considerable expansion of a yeast-food industry has taken place in Jamaica, where molasses and waste sugar are used as food for the organism (*2*). (One of the problems has been to get people to eat the yeast.) Thus, food yeast is potentially important as a means of increasing the food supply by utilization of resources otherwise unavailable to man as food.

Chlorella, a unicellular fresh-water alga, is remarkably effective in the synthesis of fats and proteins. The algae are able to convert carbon dioxide and simple inorganic compounds into organic matter, by means of light energy, through the process of photosynthesis. Dried algal cells have a protein content of about 50 percent, with a high vitamin potency. The protein contains all of the ten essential amino acids. Increase in percentage composition of fats and proteins in *Chlorella pyrenoidosa* can be achieved by changes in environmental conditions. Pilot-plant operation has shown that large-scale production is technically feasible. Extrapolation of pilot-plant results suggests that 17.5 tons per acre is a reasonable yield expectation, with present technical knowledge. The strain with the highest energy utilization produced a maximum average daily yield of 70 grams per square meter. This corresponds to an annual yield of 114 tons of dry matter per acre. This affords hope for a very greatly increased yield in large-scale *Chlorella* culture when optimum conditions for growth are better understood. Algal culture can utilize land unsuited for agriculture (*59*).

Social Implications

The social implications of the population and food problem have been a matter of sharp dispute. There has been wide disagreement between men with respect to the outcome. This quarrel, in modern times, goes back to William Godwin and T. R. Malthus. In his *Political Justice,* published in 1793, Godwin evinced unbridled optimism, with a disregard of the limitations imposed by nature. He was convinced that man, with the aid of science, could solve any problems that might arise. In his *Essay on the Principle of Population,* in 1798, Malthus challenged this position. He took a pessimistic view of the ability of man to continue to produce sufficient food in a world that combined a limited land area and a comparatively boundless capacity for human reproduction. A seesaw conflict of optimists versus pessimists has continued to this day.

As the optimists have insisted, there is undoubtedly a vast potential for increased food production in the underdeveloped countries. These countries often are characterized by a pressure of population on the food supply, a high rate of illiteracy, a low average income per person, and a concentration

of the labor force in agriculture. In peasant-agricultural countries, often more than 50 percent of the population is engaged in food production. Crop yields usually are low because of primitive production methods (*60*).

Agricultural development for increased food production is limited unless accompanied by industrial development, because of the need for critical production items such as commercial fertilizers, machines, and pesticides (*61*). The problem involves the shift from illiterate agriculturalism to literate industrialism.

Many difficulties, such as limitations in natural resources, capital, and technology, are attendant upon industrialization. The world is inadequately supplied with these requirements (*62*). Consequently, moves toward increased industrialization in underdeveloped countries place a great strain on their governments. Industrialization means dependence on science and technology. This, in turn, demands a high rate of literacy to achieve such production. Therefore, industrialization calls for improvements in education, which alone is an expensive item because it results in a much longer nonproductive period for workers. To name only a few essential factors, there must also be improvements in public health, transportation, communication, credit, and public finance. The gains that accompany these factors may, of course, be offset by an increase in population.

Conclusions

From the facts presented, it is obvious that the present accelerated upsurge of population in the world cannot be disregarded without disaster. The trends predicted by Malthus are apparent today. The world population has more than quadrupled since 1650, but the average yields of food crops per unit area of land generally have been increased at a much lower rate.

In the past, most measures used to cope with the food and population problem were stopgaps rather than ultimate solutions. The additional food needs were obtained largely from bringing more acres into cultivation. Mankind in overpopulated areas also shifted more and more to a nutritionally inadequate cereal and starchy root diet to meet his calorie requirements. He did little to control the rate of population increase.

The potential areas of new land that can be brought into cultivation in the foreseeable future are definitely limited. Further efforts to increase food production from present cultivated land will be beset with many difficulties as upper yield limits per unit area of land are approached. At the current rate of population increase of 1.5 percent per year, the limits of food production by conventional agricultural means are in sight.

There are great potentialities for increased food production in the world through widespread application of improved agricultural practices now known. Somewhat more speculative are the possibilities for the conversion of inedible or waste materials into human food. Fulfillment of the objective of more food production will require a gradual shift from an agricultural to an increasingly industrial economy in nations where population presses on the food supply. It will also necessitate intensified research in all fields of science.

It should be recognized that the theoretical possibility of a favorable balance between population and food requirements is much easier to outline than to attain in practice. There is no cause for complacency about the future so long as population increases at the present rate. The production of vast *Chlorella* farms, along with increased agricultural yields, might buy time in which the world could stabilize its population. Some measure of population control is necessary (*9*). Mankind ultimately must live within his resources or suffer the consequences of the controls imposed by nature (*63*).

References and Notes

1. *Determinants and Consequents of Population Trends*, U.N. Population Studies No. 17 (United Nations, New York, 1953); T. R. Malthus, *An Essay on the Principle of Population* (1798; reprinted by Macmillan, London, 1926).
2. E. J. Russell, *World Population and World Food Supplies* (Allen and Unwin, London, 1954).
3. M. K. Bennett, *Geographical Rev.* **31**, 365 (1941).
4. ———, *Sci. Monthly* **68**, 17 (1949).
5. W. S. Wotinsky and E. S. Wotinsky, *World Population and Production: Trends and Outlook* (Twentieth Century Fund, New York, 1953).
6. M. K. Bennett, *The World's Food* (Harper, New York, 1954).
7. R. C. Cook, *Population Bull.* **13**, 21 (1957).
8. M. Zitter, *Revised Projections of the Population of the United States, by Age and Sex: 1960 to 1975*, U.S. Bur. Census Ser. P-25, No. 123 (Government Printing Office, Washington, D.C., 1955).
9. R. C. Cook, *Population Bull.* **10**, 1 (1954).
10. R. C. Cook, in correspondence dated 6 Mar. 1957, states that "no underdeveloped country has yet effectively reduced a birth rate," even though high death rates have suddenly dropped in many such countries.
11. F. A. Pearson and D. Pearlberg, *Starvation Truths, Half-Truths, and Untruths* (New York State College of Agriculture, Cornell Univ., Ithaca, 1946).
12. W. S. Thompson, *Plenty of People* (Ronald, New York, 1948).
13. W. H. Forbes, *Federation Proc.* **11**, 667 (1952).
14. F. A. Pearson and F. A. Harper, *The World's Hunger* (Cornell Univ. Press, Ithaca, N.Y., 1945).

15. S. Brody, *Federation Proc.* **11**, 681 (1952).
16. R. C. Cook, *Population Bull.* **11**, 93 (1955).
17. ———, *Human Fertility the Modern Dilemma* (Gollancz, London, 1951).
18. G. B. Cressey, *Econ. Geog.* **29**, 1 (1953).
19. R. M. Salter, *Science* **105**, 533 (1947).
20. ———, *Chronica Botanica* **11**, 227 (1948).
21. *World Food Survey* (Food and Agr. Organization, U.N., Washington, D.C., 1946).
22. *Second World Food Survey* (Food and Agr. Organization, U.N., Rome, Italy, 1952).
23. *The State of Food and Agriculture, 1955* (Food and Agr. Organization, U.N., Rome, Italy, 1955).
24. J. D. Black and M. E. Kiefer, *Future Food and Agriculture Policy* (McGraw-Hill, New York, 1948).
25. H. H. Wooten and J. R. Anderson, *Agricultural Land Resources in the United States*, U.S. Dept. Agr. Inform. Bull. 140 (Government Printing Office, Washington, D.C., 1955).
26. *The 5th Plate*, U.S. Dept. Agr., Production and Marketing Admin. PA Circ. 191 (Government Printing Office, Washington, D.C., 1951).
27. L. A. Maynard, *Science* **120**, 164 (1954).
28. M. A. McCall, *Chronica Botanica* **11**, 273 (1948).
29. *Soil and Water Problems and Research Needs of the West*, U.S. Senate Document 98, 82nd Congr. (Government Printing Office, Washington, D.C., 1952).
30. *The Work of FAO, 1953/54* (Food and Agr. Organization, U.N., Rome, Italy, 1954).
31. D. W. Robertson, *Agron. J.* **44**, 597 (1952).
32. *Irrigation Agriculture in the West*, U.S. Dept. Agr. Misc. Publ. No. 670 (Government Printing Office, Washington, D.C., 1948).
33. F. B. Morrison, *Chronica Botanica* **11**, 247 (1948).
34. H. R. Tolley, *ibid.* **11**, 217 (1948).
35. C. E. Kellogg, "Soil conservation," address before the fifth International Congress of Soil Science, Leopoldville, Belgian Congo, 1954.
36. L. Witt, *Food Technol.* **7**, 84 (1953).
37. L. A. Maynard, *Federation Proc.* **11**, 675 (1952).
38. B. T. Shaw, *Agron. J.* **45**, 85 (1953).
39. C. H. Daniels, J. H. Boulware, W. H. Leonard *Sericulture in Japan*, Natural Resources Section Rept. No. 76 (General Headquarters, Supreme Commander for the Allied Powers, Tokyo, Japan, 1947).
40. W. H. Leonard, *J. Am. Soc. Agron.* **40**, 579 (1948).
41. K. S. Quisenberry, *Sci. Monthly* **79**, 241 (1954).
42. ———, *Chronica Botanica* **11**, 237 (1948).
43. M. T. Jenkins, *Proc. Am. Phil. Soc.* **95**, 84 (1951).
44. J. H. Martin, in *U.S. Dept. Agr. Yearbook: Science in Farming (1943–47)* (Government Printing Office, Washington, D.C.), p. 413.
45. J. R. Quinby and J. H. Martin, *Advances in Agron.* **6**, 305 (1954).
46. A. Muntzing, *Hereditas* **37**, 17 (1951).
47. S. Matsumura and A. Moshizuki, *Jap. J. Genet.* **28**, 47 (1953).
48. *Changes in Farm Production and Efficiency: 1955 Summary*, U.S. Dept. Agr. A.R.S. 43–33 (Government Printing Office, Washington, D.C., 1956).
49. J. R. Adams, U.S. Department of Agriculture, Beltsville, Md., in correspondence dated 30 June 1955.
50. *Fertilizers—a World Report on Production and Consumption* (Food and Agr. Organization, U.N., Rome, Italy, 1952).
51. F. E. Bear, "Food for thought about food," presidential address, American Society of Agronomy, 26 Oct. 1949.
52. C. G. Painter and R. W. Meaner, *Agron. J.* **45**, 261 (1953).
53. C. G. Decker, *Agr. Chemicals* **9**, 36, 111 (1954).
54. R. M. Blouch, *Sci. Monthly* **76**, 36 (1953).
55. F. J. Witt, *J. Agr. and Food Chem.* **3**, 388 (1955).
56. *The Work of FAO, 1952/53* (Food and Agr. Organization, U.N., Rome, Italy, 1953).
57. K. Kuronuma, *Carp Culture in Rice Fields as a Side Work of Japanese Farmers* (Ministry Agr. and Forestry, Japan. Govt., Tokyo, 1954).
58. E. D. Hawkins, *Current History* **25**, 261 (1953).
59. J. S. Burlew, *Algal Culture from Laboratory to Pilot Plant*, Carnegie Inst. Wash. Publ. 600 (Washington, D.C., 1953).
60. K. Davis, *Proc. Am. Phil. Soc.* **95**, 8 (1951).
61. H. R. Tolley, *ibid.* **95**, 54 (1951).
62. J. J. Spengler, *ibid.* **95**, 20 (1951).
63. I wish to acknowledge the assistance of Robert C. Cook, director, Population Reference Bureau, Washington, D.C., for helpful criticism on the treatment of the population problem as well as for the charts used in connection with this article. Byron T. Shaw, administrator, Agricultural Research Service, U.S. Department of Agriculture, Washington, D.C., offered valuable suggestions on the material on potential food production.

Training of a Scientist

VAN CLEVE MORRIS

Dr. Morris is associate professor of education in the School of Education, Rutgers University, New Brunswick, New Jersey, and coordinator of teacher education at Douglass College, the women's coordinate division of Rutgers. He received his training at Oberlin College and Teachers College, Columbia University, and did postdoctoral study at Harvard University, Catholic University of America, and New York University. This article is based on a paper that was presented before the Louisiana Section of the American Chemical Society on 12 October 1956, in New Orleans.

MUCH has been said in recent months on the problem of the shortage of scientific and technical personnel in the United States and what should be done about it. One hesitates, therefore, before raising one's voice again on this question, for fear that the whole business will begin to pall. If this should happen, it would be unfortunate, for we do indeed face a very serious predicament in American life, in which both scientists and educators have a vital interest. And we cannot resolve difficulties of this magnitude merely by turning from them when they most need our attention.

Furthermore, avoiding discussion of situations like this may give the impression to some that there is nothing so seriously wrong that a few dollars, or a few laws, or even a few honest intentions cannot correct it, and that the problem is not as difficult and insoluble as the "hand-wringers" are making out. When this impression is given, we are in trouble, for the difficulty we face with respect to our supply of scientific personnel is considerably more involved and complex than laymen, scientists, or educators think.

Some Popular Misconceptions

Before we get too far, it is important to put to rest, permanently and conclusively, some pernicious misconceptions that have crept into public conversation, nationally, on this question, all being the result of an effort to oversimplify an essentially complicated question. These misconceptions have to do with the culpability of the public school in the present predicament. Three misconceptions, in particular, I am anxious to dispose of.

Misconception number one: "Schools are not emphasizing science in their programs." This idea has been propagated across the land by a variety of individuals, one of the more prominent being Lewis L. Strauss of the U.S. Atomic Energy Commission. Before the Thomas Alva Edison Institute, a couple of years ago, Strauss made the remark that 53 percent of the nation's high schools offer neither chemistry nor physics. A study (*1*, p. 6) made by the U.S. Office of Education reveals that this is a long way from being the truth. The figure is only 23 percent; and this 23 percent of the schools enroll only about 6 percent of the pupils. These are small high schools, mainly in the rural areas, many of them in the South, and they cannot support these programs. But 94 percent of our high-school youngsters attend schools where chemistry or physics is available!

Misconception number two: "High-school students are not studying science as much as they used to." How about this? In a 1956 study of the Baltimore public schools (*2*) it was learned that, in the 21 years from 1934 to 1955, the percentage of students who took physics dropped from 22 to 15 percent but the proportion of those who took chemistry remained almost steady, dropping slightly from 15 to 13 percent, and the group who took biology increased from 24 to 30 percent. In the state of New Jersey, in which every single high school offers all the customary studies in science and mathematics, from biology, chemistry, and physics to advanced algebra, geometry, and trigonometry, a similar study (*3*) revealed that, in the 37-year period from 1918 to 1955, the proportion of those who took physics dropped from 9 to 7 percent, the figure for chemistry held steady at 9 percent, and that for biology rose from 11 to 20 percent. All in all, the group of students who took some science in high school rose from 47 percent in 1918 to 60 percent in 1955, and the group who took some mathematics held steady at about 60 percent during this 37-year period (*4*).

Nationally, the U.S. Office of Education reports a similar pattern over the 40-year period from 1915 to 1955. The percentage dropped for physics, remained steady for chemistry, and increased for

biology (*5*). In the fall of 1954 the percentage of our young people who were taking physics was 24 percent (one in four); chemistry, 32 percent (one in three); and biology, 73 percent (three in four) (*1*, p. 9, Table 3).

Misconception number three: "Science, as an intellectual discipline, is out of favor in the educational profession." We hear all kinds of pronouncements these days about the subversive activities of the die-hard progressive educationist who is personally interested only in the questionable practice of developing the "whole person." Not the least of such statements was the recent utterance of Joel Hildebrand (*6*), in which we learn that school authorities have launched a magnificent program to deintellectualize America. The fact that such statements as this can come from a scientifically trained mind in our time makes one wonder whether science—as a way of thinking, as a method of inquiry, as an intellectual outlook—has progressed any further than frogs, test tubes, and the reading of meters.

Social Factors

I shall examine this suspicion in a moment, but, in anticipation of that analysis, it would be helpful to examine the true dimensions of the problem here under consideration. Like most problems in the social sciences, and unlike those in the physical sciences, the problem of shortages of scientific personnel is characterized by social and cultural factors which operate at considerable "distance" from the ordinary layman. As such, they are obscure and incomprehensible, except when they are interpreted by social scientists. Concerning the present problem, I mention three such factors.

First, there has been, in the past generation or two, a startling realignment of our manpower requirements. Abram J. Jaffe and Charles D. Stewart, in their book, *Manpower Resources and Utilization* (*7*), have found that the proportion of our working population in the professional, technical, and white-collar managerial occupations has increased markedly. While fewer and fewer individuals are needed on our farms, for instance, more and more are needed in our offices, technical centers, and research laboratories. We are a society that is increasingly dependent on technical skills, and World War II and the highly charged years that have just passed have only helped to aggravate the situation still further by stimulating this need far beyond anything that our educational system could reasonably expect.

Second, the birth rate has come into the act again. Just when we need the greatest number of highly trained people to man our industrial technology, at the very moment that this demand is at its zenith, we find that there is only a trickle of individuals coming out of our colleges and training centers. Why is this? Simply because 20 years ago, when they were being born, there were not enough of them. The lavish procreative habits of recent times had not yet come into vogue in the 1930's, and, as a result, there was a serious depression, not only in the business cycle, but in the reproductive cycle as well. This "trough" of population is now of college age and represents the trainable segment of our population, but there are not enough of them to go around. Coupled with this is the sudden rise in the birth rate that occurred during the late 1940's and 1950's, which has had the effect of producing a new enlargement of the population and, hence, a new and unforeseen increment in the demand for the services of the technical employee. The shortage of trainable individuals and the surplus of individuals to be served is a simple demographic phenomenon, a matter of plain arithmetic.

Third, the low estate of both the scientist and the teacher of science has become alarmingly evident in recent years. The scientific worker is increasingly regarded as an odd kind of person who works on material which is not only politically secret but technologically so erudite that no ordinary person can comprehend it. With this stereotype in mind, the youngster who is planning a career finds it difficult to visualize himself in an occupation that he does not know anything about. And when he confronts scientists of his acquaintance, his high-school science teacher for instance, he may run into other confusions that characterize our puzzling social system. I refer to the fact that the teacher of science, being a teacher, unfortunately inhabits the lower socioeconomic echelons of society and too infrequently stands as the symbol of excitement and adventure for which a youngster in high school is looking. In view of these conditions, many people turn away from science, despite the generous rewards that are now being offered by industry.

The Scientific Mind

These are some of the more obscure features of our predicament, and I mention them precisely because they are obscure. Possibly just as obscure, but no less urgent, is the matter of the role of the scientific mind in modern life. I referred in an earlier paragraph to the current lament that science is losing out in the school program because it

has lost favor among educators. In the first place, it has *not* lost out in the secondary schools of this country, as the studies which I have cited have shown, and this is true in spite of the fact that a constantly increasing proportion of our young people attend school. Furthermore, science has not lost favor in the educational profession. On the contrary, it is precisely the scientific mentality which the modern educator is in search of. Indeed, I think the greatest single task we face today is emphasizing the importance of the scientific mind in solving the problems of life. And I shall make my case by being blunt and coming directly to the point, to mix a couple of metaphors.

Scientists, I know, have their misgivings about educators, but educators have a major cause for disenchantment with scientists, not with all of them by any means but with a dishearteningly large number of them—namely, that they are magnificently capable of scientific thinking in their own fields but are insufficiently attentive to the need for scientific thinking when it comes to problems in the social life of America, problems precisely like the one under view. How else can we explain the comment of Strauss, a leading spokesman for the scientific community, that more than half of the American high schools do not teach either chemistry or physics? How else can we explain the claim in the January 1956 quarterly report of the Carnegie Corporation that "a third of the states require no mathematics for certification of math teachers," a remark that a respected editor of a professional education journal spoke of, after some careful investigation, as "not within shooting distance of the truth" (*8*)? How else can we explain the more recent display of dubious logic by Strauss in a remark, apparently based on the afore-mentioned faulty datum, that "one-third of our youngsters are studying mathematics under instructors not qualified to teach it" (*9*)? Even if the Carnegie Corporation figures were correct, which they are not, what warrant does one have for making such a statement as this?

Finally, how else can we explain the questionable and intemperate scholarship of Hildebrand, who, instead of thoughtfully criticizing the ideas of John Dewey as presented in one of Dewey's own works, proceeds to make his case against this educational theorist by vague reference to a third-hand source (a book about a friend and interpreter of Dewey), together with the testimony of some disgruntled graduate students who write Hildebrand unsolicited letters? Is this the way to seek truth? A social scientist would never consider this an appropriate working procedure, but a physical scientist, and a respected one at that, apparently considers this the way to discuss education in America.

Why do scientists permit themselves the left-handed luxury of such unscientific behavior? Why do scientists who have earned the admiration of the whole world for their marvelous feats of scientific thinking in the laboratory feel privileged to abandon the temperate and objective road to reason after 5 o'clock?

This is not so much a rebuke of scientists as of educators. I am really talking to myself and to all professional people who are in the business of training technical personnel and scientists. Somehow, somewhere we have failed to provide the kind of educational experiences that lead to scientific attitudes in social affairs.

Science is a cherished tradition in the West. Our progress in science stands as a stupendous and spectacular intellectual achievement, by means of which civilized man has won marvelous mastery over his physical environment. In a very literal sense, we have achieved what man has so mightily striven for in all his long and tortuous history—conquest over the physical world in which he lives.

Our next task, so forcefully apparent in the 20th century, is to gain mastery over ourselves. It is now the human environment that is the problem. Here in this social universe are the forces which threaten the survival of modern man, just as wind and weather did in earlier periods. And the truth of the matter is that we stand, in our understanding of these forces, about where the savage stands in his understanding of the elements.

And how do we get from savagery to civilization in social understanding? In the same way that we have reached a state of civilization in our technologic life, through the magnificent medium of science. Science is not just a matter of frogs, test tubes, and meters. It is a way of thinking that can liberate the human mind from passion, prejudice, and uncriticized custom in all departments of life. As such, the scientific attitude is destined to become the prevailing mood of our time, reaching into and illuminating all the dark and obscure corners of human experience. Our task is to make it a part of the intellectual equipment of all young people, so that it may increasingly operate in the social sphere as it has operated so fruitfully in the physical. If scientists could join educators in this undertaking, we would certainly be on the right path to a more humane and intelligent use of science in American life.

References and Notes

1. K. E. Brown, *Offerings and Enrollments in Science and Mathematics in Public High Schools* U.S. Office

of Education, Dept. of Health, Education, and Welfare, pamphlet No. 118 (Washington, D.C., 1956).
2. L. H. Woollatt, "Subject Enrollment Trends in Baltimore Senior High Schools 1934–1955 with Particular Reference to Science" (unpublished study).
3. *Science and Mathematics Teaching in New Jersey Public High Schools,* New Jersey Dept. of Education Research Rept. 179 (May 1956), p. 2, Table 1.
4. Both the Baltimore and the New Jersey studies measured enrollments in science courses in a given semester against the total enrollment of the school in that semester. Since many sciences are not taken until the junior or senior year, this method yields an erroneous underestimate of the actual proportion of students who are enrolled in these courses at some time during their secondary-school years. Thus, the figures for the Baltimore and New Jersey studies are presented here primarily for purposes of comparison.
5. Figures from the U.S. Office of Education study are the result of calculations which have corrected the error noted in 4.
6. J. Hildebrand, "Intelligence is important," *Chem. Eng. News* (17 Oct. 1955).
7. A. J. Jaffe and C. D. Stewart, *Manpower Resources and Utilization* (Wiley, New York, 1951), chap. 12.
8. T. M. Stinnett, *J. Teacher Education* (Sept. 1956), pp. 194, 267.
9. *New York Herald Tribune* (10 Oct. 1956).

Rare Photograph of Middle Ear Bones

The middle ear ossicles of an adult male as shown in relation to the head of an ordinary straight pin provide the subject for our cover this month. Clearly depicted are the stapes (stirrup-shaped structure), the incus, and the malleus. The photograph was made by Myron R. Kirsch, director of special education for the Garden Grove Union High School District, Garden Grove, Calif. The ossicles were obtained from an instructional skull, male, Asiatic (Indian) approximately 40 years of age. The incus was attached to the head of an ordinary straight pin by means of a transparent adhesive, and the subject was photographed against a medium gray poster-board background. The resulting image was enlarged a great many times.

IGY Rocket Program

SUBCOMMITTEE FOR IGY OF THE
TECHNICAL PANEL FOR ROCKETRY

This article was prepared on behalf of the committee by N. W. Spencer, director of the upper atmosphere research program of the electrical engineering department of the University of Michigan, Ann Arbor. Other members of the committee are H. E. Newell, Jr., Naval Research Laboratory, chairman; K. A. Anderson, University of Iowa; W. W. Berning, Ballistics Research Laboratory; L. M. Jones, University of Michigan; R. M. Slavin, Air Force Cambridge Research Center; and J. W. Townsend, Jr., Naval Research Laboratory.

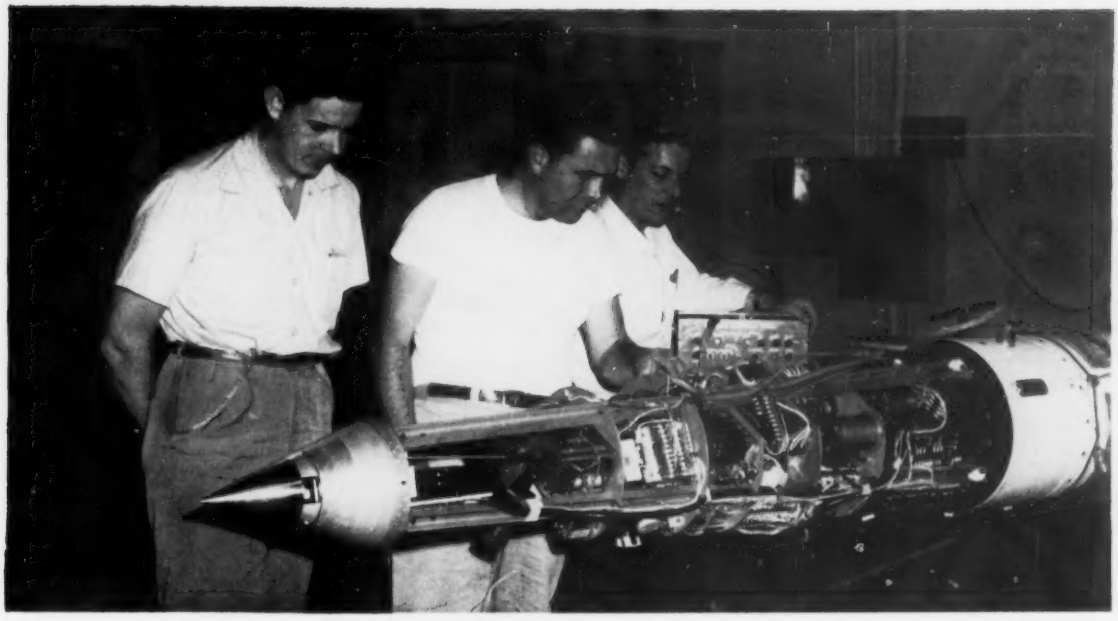
COMMENCING in July of this year and extending through 1958, about 200 rockets, carrying a multitude of instruments of established capabilities, will be launched into the earth's atmosphere, in some cases to altitudes of nearly 300 kilometers, to transmit information about high-altitude phenomena to ground-based recording devices. This period of intense, direct probing of the earth's environment will embrace many disciplines of science and will constitute a significant portion of the United States' program for the International Geophysical Year (IGY).

Support for the scientific aspects of this program, to be carried out by several defense establishment laboratories and universities, is provided largely by the Department of Defense through the three military services. Significant and substantial additional support is being made available by Congress through the National Science Foundation. The National Science Foundation acts as fiscal agent for the National Academy of Sciences, which established the United States National Committee for the International Geophysical Year (*1*) for the purpose of coordinating the administrative and fiscal, as well as the scientific, aspects of the over-all United States program. A considerable supporting logistics effort has been organized on an interservice basis. The Ordnance Corps of the Army has the over-all responsibility for the establishment and operation of an arctic rocket-launching site, the Navy's Bureau of Ordnance has the responsibility for preparing and launching the various rockets, the Signal Corps of the Army has broad responsibilities for range instrumentation, the Navy will supply extensive shipboard support for rocket launchings at sea, and the Air Force will provide the considerable air transport required for the planned operation.

The Upper Atmosphere Rocket Research Panel (*2*), an unofficial and informal group of scientists engaged in atmospheric exploration by means of rockets, provided a natural medium for the early consideration and organization of an IGY rocketry program, prior to the establishment of the official IGY panel. A subcommittee of the Upper Atmosphere Rocket Research Panel, known as the Special Committee for the IGY (*3*), was appointed to provide the necessary operational planning of the program, including establishment of a launching facility in the arctic, scheduling of launching, and coordination of the logistic support provided by the Department of Defense.

The U.S. National Committee for the International Geophysical Year organized its efforts under a number of panels, most of them concerned with specific areas of geophysics such as meteorology, geomagnetism, the ionosphere, solar activity, glaciology, and several others. A special panel, concerned with the rocket research program, was named, and to this panel, called the Technical Panel for Rocketry (*4*), the IGY functions of the Upper Atmosphere Rocket Research Panel were transferred. The Special Committee for the IGY was then reappointed as a subcommittee of the Technical Panel for Rocketry and was assigned the additional task of providing operational management of the program.

The international aspect of this scientific program has been enhanced by the generosity of the Canadians, who extended a welcome invitation to United States scientists to conduct a portion of the rocket program in the important arctic regions at Fort Churchill on Hudson Bay. Although most upper-atmosphere investigation by rockets has been conducted in the New Mexico desert, the rocket-probing techniques that have been developed and the high-altitude information that has been acquired at that point on the earth's surface by means of rocket firings have, in addition to adding to geophysical knowledge, served to em-



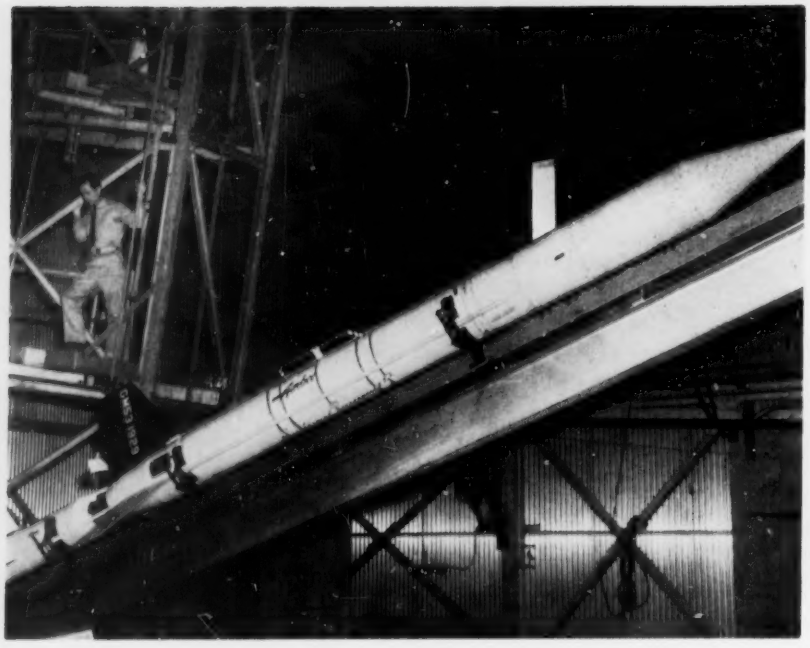
U.S. Air Force Aerobee instrumentation test. The Aerobee was designed specifically for upper-atmospheric research.

phasize the scientific importance of conducting similar experiments at other latitudes. In particular, knowledge of the earth's ionosphere gained primarily through direct rocket probing, and more recent concepts of the important role played by solar radiation in the formation of the ionosphere and of its established and conceivable effects on communication, weather, and related phenomena, have demonstrated the importance of intensified, direct experimentation in the earth's arctic auroral zone, which (conveniently) includes the Fort Churchill area. Investigations leading to a better understanding of the underlying causes of the aurora, an ionospheric phenomenon, will assist in furthering our comprehension of the ionosphere and related solar processes. Of equal if not greater significance to an understanding of weather phenomena is the extension of meteorological rocket investigations to the polar regions. Thus, an opportunity to conduct experiments at different latitudes, and particularly in the polar regions, is scientifically important, of practical value, and extremely challenging.

A substantial fraction of the rocket program will be devoted to experiments (described later in this article) designed to provide information which will increase our knowledge of important ionospheric phenomena. These studies will have as their objectives measurements of day and night airglow, solar ultraviolet spectrum, Lyman alpha emissions, x-ray intensity, air fluorescence, charge density in the ionosphere, and the magnetic fields of the ionosphere and the earth. An additional group of experiments involving the measurement of cosmic-ray intensities will be conducted at Fort Churchill and in antarctic and arctic regions.

The remainder of the program at Fort Churchill is equally important because it will be devoted, essentially, to the determination of parameters generally associated with atmospheric structure. In this area, measurements leading to the determination of air pressure, temperature, density, composition, movement (winds), and water-vapor content will be made.

Although, for the foregoing reasons, much effort will be concentrated in the Fort Churchill region, many substantially identical but generally less complex experiments will be conducted at alternative geographic locations. Although many rocket flights will be conducted in New Mexico, extensive experimentation at sites other than the New Mexico desert will not be possible, owing primarily to the somewhat primitive state of development of means of providing necessary supporting activities, such as trajectory determination and data recording. Certain experiments which require only sufficient position-in-space information to make it possible to assign altitudes to resulting data will be employed rather extensively at many geographic locations. To this end, shipboard launchings will afford a mobility which is clearly desirable. Thus, experiments of this type include, essentially, those which can be adapted to the smaller and more economical rockets that do not require extensive ground facilities.



U.S. Signal Corps grenade experiment Aerobee rocket is raised into tower preparatory to launching.

The Rocket Vehicle

Rocket exploration of the upper atmosphere by United States scientists over the past 10 years has been accomplished through the employment of relatively few types of rockets, primarily because of the great expense incurred in their development. The first to be employed to a substantial degree was the German V-2, a large rocket (over 40 feet in length and weighing nearly 15 tons at take-off), some 40 to 50 of which successfully carried upper-air instruments aloft. The deterioration (in the physical sense) of the V-2's and particularly the expense of conducting experiments on a scale where the risk associated with a particular launching was likely to be excessive, spurred, at an early date, the development of the Aerobee rocket, a much smaller, less expensive, and less complicated vehicle (25 feet in length, weighing roughly 1 ton, including the booster rocket), designed specifically for upper-atmospheric research purposes. Very successful use of the Aerobee (over 160 flights) has been made during the past decade; this indicated that its use during the IGY program was desirable. Several different models, of varying capabilities, are currently available and will be used during the program.

Somewhat paralleling the Aerobee development and use program has been a similar but less extensive activity involving the Viking rocket (35 feet in length and approximately 4 tons in weight), which may be considered to stand, roughly, halfway between the Aerobee and the V-2 in instrument capacity and vehicle complexity.

More recently, considerable effort has been expended in the direction of providing a rocket combination for use in upper-air sounding that will be substantially less expensive than either the Viking or Aerobee. The development of dependable probing techniques and the desire to work in the direction of measurements which the vehicles mentioned above make possible have increased the attractiveness of relatively small (6-inch-in-diameter) rockets. Various launching schemes which greatly enhance the payload-trajectory characteristics of such rockets are at present in a more or less advanced state of development.

For example, a technique which has been used quite successfully since 1952 illustrates one direction in which a solution to the problem of providing relatively inexpensive means for upper-air probing may be found. A small instrumented rocket, much less expensive than an Aerobee, is attached to a large helium-filled balloon, which, when released, elevates the rocket from 15 to 20 miles above the earth, where the rocket is then fired. An important result of this approach is that most of the earth's denser atmosphere is bypassed through use of the balloon; this permits the rocket to attain considerably greater altitudes.

Another technique which yields a similar result employs an additional rocket motor (Jato) to boost

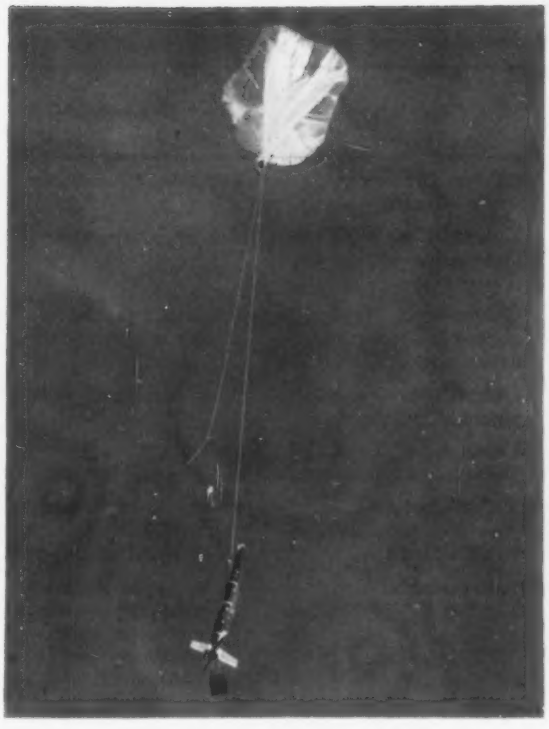
the small rocket to the firing point, above a significant portion of the denser atmosphere. This method makes for greater flexibility, mobility, and ease of launching than the balloon technique but has the moderate drawback of causing troublesome heating of the instrumentation compartment, under some conditions, during passage through dense air at high velocity.

Neither the Viking nor the now obsolete V-2 will be employed in connection with the IGY program. However, both the Aerobee and the small rockets—called "Rockoon" when balloon-launched and "Nike-Cajun" when Jato-launched—will be used extensively. Launchings of Aerobees will be accomplished at Fort Churchill and at the New Mexico proving grounds, whereas the smaller rockets, it is expected, will be launched at many points, from Guam to Fort Churchill to the antarctic. The altitude that is reached by a particular rocket combination is largely dependent on the weight of equipment that the rocket must carry aloft. In general, Aerobee rockets will reach greater altitudes than the smaller rockets. They will be relatively lightly loaded (in some cases the load will be as little as 120 pounds) when comparatively high altitudes (roughly, 175 miles) are desired for a particular experiment. The small rockets, when comparably loaded in relation to their capabilities, will attain altitudes of approximately 100 miles. Heavier loading will, in each case, substantially reduce the attained altitude.

Participating Research Organizations

The organizations and scientists conducting the scientific investigations constituting the IGY rocket program, which has been accepted and endorsed by the Technical Panel for Rocketry and, in turn, by its parent body, the United States National Committee, include most of those groups which have been engaged in upper-atmosphere research, through the use of rockets, since the initiation of such research after World War II.

Table 1 lists the participating service and university laboratories alphabetically. The universities represented generally conduct their research programs under the sponsorship of the service agency indicated. It should be noted, however, that in each case a desirable and extensive degree of scientific freedom is enjoyed by the university groups—a worth-while arrangement which contributes to the advancement of research programs of this type and which reflects credit on the sponsoring agencies. It is of interest to note that, at the universities represented, many graduate students are active in supporting efforts that are essential to the success of the individual programs and are in some cases active in responsible positions.



A Rockoon in flight. (U.S. Navy–University of Iowa project.)

The references (*5*) at the end of this article serve to provide background information concerning the rocket research which forms the basis for this IGY program and will identify the individuals who have been, and are currently, associated with the effort.

IGY Rocket Experiments

Table 1 presents, in summary form, a listing of organizations participating directly in the rocket effort and their corresponding objectives in the IGY rocket instrumentation program, with a tabulation of the number and type of rockets that are to be employed to carry the measuring instruments to the desired altitudes. Accordingly, by reference to the table, it is possible to envision the entire program and to note the relative involvement of the various participants.

In order to permit clearer comprehension of the scientific objectives and the associated means for their attainment, there follows a brief discussion of the various experiments that are planned. The grouping in the discussion is intended to indicate the general extent of the program.

Table 1. Organizations participating directly in the rocket effort and their corresponding objectives in the IGY rocket instrumentation program, showing number and type of rockets that are to be employed.

Organization	Research object	Aerobee rockets		Small rockets	
		No.	Location	No.	Location
Air Force Cambridge Research Center	Dayglow, solar ultraviolet	3 2	New Mexico Fort Churchill		
University of Michigan aeronautical engineering department	Density, temperature			4	Fort Churchill
University of Michigan electrical engineering department	Pressure, temperature, density, and winds	3	Fort Churchill	12	Fort Churchill
University of Colorado physics department	Solar ultraviolet radiation	1	New Mexico		
University of Utah physics department	Ionosphere charge density	3 3	New Mexico Fort Churchill		
Ballistics Research Laboratory, Aberdeen Proving Ground	Water vapor, ionosphere, magnetic field, cloud pattern			10 2	Fort Churchill New Mexico
Naval Research Laboratory	Ozone, solar ultraviolet radiation, pressure, temperature, density, x-rays, ionosphere aurora particles, ion composition	5	New Mexico	6	Pacific Ocean
U.S. Army Signal Corps Engineering Laboratories	Temperature, winds	17	Fort Churchill	8	Guam
University of Michigan aeronautical engineering department (with USASEL)	Temperature, winds	8	Fort Churchill		
University of Iowa (ONR–State of Iowa) physics department	Cosmic rays, auroras, magnetic field			16 31 55	Fort Churchill Arctic and subarctic Antarctic and equatorial

The majority of the experiments to be described are concerned with aspects of the earth's atmosphere, including (i) its density, temperature, pressure, movements (winds), and water-vapor content; (ii) its solar-related constituents, including ionized particles and ozone, for example; and (iii) the various solar emanations. An additional important class of experiments, those concerned with cosmic rays, is not included in this grouping, for cosmic rays may originate outside the solar system. The latter point is highly controversial.

Data Transmission and Recording

One of the problems encountered in upper-atmosphere research with rockets is that of reception, on the ground, of the data produced by the instruments carried in the rockets. Clearly, reliability of transmission is as essential to the success of the program as the successful operation of the measuring instruments. To this end, most of the rockets to be launched will carry a radio transmission system, called a telemeter. This device will make possible the nearly simultaneous transmission of many (in some cases perhaps almost 100) voltage magnitudes, which will be recorded on film immediately on their reception on the ground. Thus, later analysis of the voltage magnitudes and subsequent interpretation in terms of scientific information becomes possible.

Atmospheric Regions of Interest

As a vehicle ascends from the surface of the earth, it passes through various strata, characterized most commonly by temperature but also, at times, by chemical and electric properties. It rises, in succession, through the troposphere, stratosphere, ozonosphere, ionosphere, and exosphere. The exosphere is an outer "stratum" which merges, at some unknown level, with outer space. The ionosphere is generally considered to begin, in the

Scientists prepare to launch a Rockoon at sea. These small rockets will be used extensively during the IGY program. [Naval Research Laboratory]

daytime, at an altitude of about 60 miles, the ozonosphere at about 20 miles, and the stratosphere —relatively close to the earth—at about 7 to 9 miles. The lowest region, the troposphere, constitutes over 80 percent of the total mass of the atmosphere.

Balloons afford relatively ready access through, and to, the upper portions of the stratosphere and, compared with rockets, provide a desirable and economical means of probing these regions. Thus, rocket measurements are generally not desirable below altitudes of 20 to 30 miles and are considered worth while only at higher altitudes, the maximum being limited by the altitude capability of the rocket vehicle or by the limitations of the system of measurement.

Temperature, Pressure, Associated Parameters

Temperature, pressure, and associated parameters are significant at all attainable altitudes, and experiments to be conducted for these quantities will comprise an important phase of the program. Initially, it may seem that sufficiently precise measurements of pressure and temperature might be readily achieved through use of some minor variation of standard techniques employing thermometers, aneroid pressure gages, and related devices. However, the experimental conditions imposed by the generally very high velocity of the rocket and the very great range of values encountered, particularly in the case of air pressure and density, render such methods essentially useless.

The great velocity of the rocket results in several important effects. (i) Little time is available to make, transmit to the ground, and record a measurement. (ii) The rapid movement of air past a pressure-measurement port on the surface of the rocket alters the value recorded from that of the ambient pressure, which is the measurement desired. (iii) The air, as it moves past the rocket, can cause excessive heating of the rocket and possibly of surface-mounted instruments as well.

These deleterious effects have been largely overcome or effectively avoided through means developed over the past several years of upper-atmosphere probing. In some cases, the seemingly pernicious effects have been turned to the advantage of the experimenter and have resulted in techniques which permit measurements that are in many cases better than one might expect to obtain in a less trying environment. An experiment that has been developed by the U.S. Army Signal Engineering Laboratories, and which will be conducted in Aerobees during the IGY program by the Signal Corps, jointly with the University of Michigan's aeronautical engineering department, will measure temperature and winds in the following fashion. As the rocket passes through the atmosphere, grenades are ejected periodically and exploded at known times and altitudes. The arrival times of the resulting sounds of explosions at the ground are recorded. Since the altitude separations of the explosions and the differences in time of arrival are known, it is possible to compute the velocities of sounds corresponding to the various altitude increments and thus to determine average temperatures for the altitude interval. Further

Instrumented Nike-Cajun rocket is erected for launching. (U.S. Air Force–University of Michigan project.)

measurements of the angles of arrival of the sounds at the ground permit computation of the average winds in the various intervals. This method is useful for temperature measurement to altitudes of about 60 to 65 miles; above this point the sound propagation parameters are not sufficiently well known.

Most of the measurements of pressure, temperature, and related parameters to be made depend on aerodynamic properties of the air flow about high-velocity bodies. In one case, in an experiment developed under U.S. Air Force sponsorship by the University of Michigan's aeronautical engineering department, a sphere 7 inches in diameter will be carried to a high altitude and then permitted to drop freely through the atmosphere. The deceleration of the sphere due to increasing air density will be measured and telemetered to earth, and from these data, and from a knowledge of the drag coefficient for the sphere, the corresponding air density will be computed. Then, through use of the hydrostatic equation, the temperature as a function of altitude may be calculated.

Another experiment developed by the University of Michigan's electrical engineering department under Air Force sponsorship may be described as follows. The ratio of the velocity of any object to the velocity of sound in the same medium is known as the Mach number. Since the velocity of sound is dependent on the temperature, as noted in the description of the grenade experiment, the Mach number is clearly thermodependent and thus can form the basis for temperature, pressure, and wind measurements. Accordingly, pressure gages are mounted at the very tip and on the side of the nose cone of a rocket, and the changing pressure, throughout flight, is recorded. The pressure at the tip of the nose is generally many times greater than that on the side wall because of the velocity of the rocket, and, furthermore, the ratio of these two pressures is directly related to the Mach number. Thus, from a consideration of the Mach number and the rocket velocity, which will be known, the temperature may be determined. Ambient pressure is also deduced through use of the same gages, which are, in this case, ionization gages.

The Mach number may also be measured independently on the same rocket from a knowledge of the angle of flow of air over the surface of the nose cone, when the rocket flies at some angle to the air stream, as is generally the case. Further consideration of these flow-angle data in connection with the pressure-measurement-determined temperatures permits computation of the wind velocity.

The Naval Research Laboratory will conduct measurements of pressure and density by alternative but somewhat similar means. Special diaphragm and ionization manometers will be mounted, with their parts exposed to the air stream, at various locations on the rocket's surface, to measure the pressure and pressure modulations on the rocket as it rolls during flight. The resulting changes in pressure observed as the measurement ports are brought first "into the wind" and then "away from the wind" will permit computation of air density as a function of altitude. This experiment is particularly interesting because the experimental technique employed permits extension of the measurement of density to a higher altitude than would be possible without utilization of the modulation effect, and to a higher altitude than is permitted by other methods.

A single pressure measurement at the tip of the rocket comprises a companion experiment and permits an air-density computation by reference to Pitot tube relations.

Some 50 to 75 rocket flights will be conducted for determination, by the foregoing methods, of pressure, temperature, density, and winds. They will be scheduled at appropriate times throughout the IGY period to provide a reasonably comprehensive picture of the seasonal variation and, in some cases, of the diurnal variation of these parameters. Most of the data will be obtained at altitudes of less than 60 to 70 miles, with probable error ranging from 1 to 15 percent, depending on the method, for it is the altitude region up to this

level that has received the greatest emphasis over the past several years and that has been most readily and frequently accessible by rocket. There will be relatively few measurements above this region; these will be significant, but it is expected that the precision will be less.

Concentration of Ozone

Other flights will be conducted to determine data concerning atmospheric composition, with emphasis on constituents such as ozone, nitrous oxide, and water vapor. Of special interest is the ozonosphere, a region of atmosphere where, under the influence of solar radiation, ozone (O_3) is formed from molecular oxygen. Ozone has the property of absorbing solar ultraviolet radiation very strongly and thus protects man from excessive ultraviolet radiation. Because of this absorption, the temperature in the ozonosphere rises to nearly that of the earth's surface.

The concentration of ozone in this region as a function of altitude is a matter of scientific interest and importance and will be measured by means of a spectrometer, which will record the ultraviolet spectrum of the sun as the rocket passes through the ozonosphere. From the changing absorption detected by spectrum analysis, the total ozone content can be determined. This experiment will be performed by the Naval Research Laboratory, employing an Aerobee rocket.

The Air Force Cambridge Research Center will conduct a somewhat similar experiment, utilizing a spectrograph to determine the presence of nitric oxide (NO) and other gases thought to exist in the upper atmosphere, concerning which there is a paucity of data. An interesting feature of this experiment and of the ozone measurement that has been described is the use of specially designed pointing controls which act to orient the spectrographs in the precise direction of the sun, quite independently of angular or other motions of the rocket; this has the effect of maximizing the amount of data obtained.

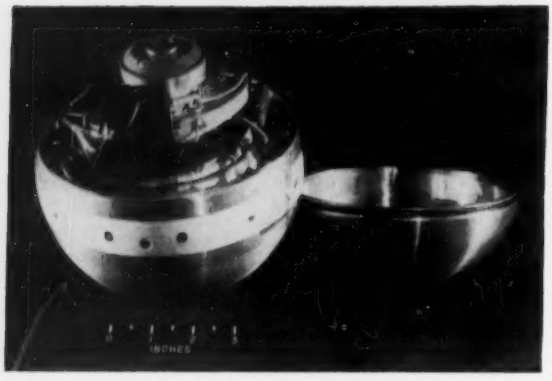
Another constituent of the atmosphere, water vapor, will be measured in a fundamentally similar fashion by scientists of Aberdeen Proving Ground. A knowledge of water-vapor content will, it is believed, be of assistance in determining the nature of clouds that have been observed at extremely high altitude (40 to 50 miles) and that are referred to as "noctilucent" clouds. It has been determined in the laboratory that water-vapor content may be determined with sufficient precision by observing the relative absorption at infrared wavelength; thus, a desirable upper-air experiment can be made.

Naval Research Laboratory Aerobee rocket, Fort Churchill, Canada.

The Ballistics Research Laboratory will perform an additional experiment to obtain measurements of the photometric properties of the atmospheric layer at the horizon, as it is observed from altitudes of from 20 to 60 miles. Photography, with infrared-sensitive film, of the horizon as the rocket ascends permits study of the cloud coverage pattern; this, in turn, leads to a better understanding of high-altitude storm patterns. Detection of such phenomena from the earth is, in many instances, impossible; thus, this technique will permit further study of these meteorological effects.

Airglow

Observation of the light emitted by the upper atmosphere (exclusive of auroras) has shown that atmospheric emissions from the twilight sky are many times greater than those from the night sky. Such data imply that direct solar energy produces resonance processes in the upper atmosphere—an effect which may be substantiated theoretically. However, assessment of the efficiency of many of these processes is difficult, and thus experimentation which will permit direct measurement of these relative unknowns is desirable. Accordingly, the



Sphere employed in falling-sphere experiment for air-density measurement. (U.S. Air Force–University of Michigan project.)

intensity and spectrum of the day and night airglow as a function of altitude will be measured; the resulting data will make it possible to secure information regarding the source and height of the emission, the associated atmospheric elements, and the energy exchange. Spectral regions of particular interest are those where sodium and oxygen emit light.

To perform these measurements, the Air Force Cambridge Research Center will use calibrated photometers that employ photomultiplier tubes with multipass interference filters which sweep through a selected 1000-angstrom band of the visible region to provide resolution equivalent to a 10-angstrom pass band.

Magnetic Field

A relatively independent class of experiments will be devoted to studies of the earth's magnetic field and of effects which are believed to cause variation of the field. All experiments that have been planned to date will effect measurement of the strength of the total geomagnetic field and of its components.

Electrical currents flowing in the lower levels of the ionosphere have long been supposed to be responsible for the diurnal variation of the geomagnetic field and, to some degree, for the sporadic magnetic storm effects which may be observed, on occasion, at the ground. A need for verification of these theories, particularly with reference to the auroral zones, provides a strong incentive for undertaking these experiments.

Three organizations—the University of Iowa physics department, the Naval Research Laboratory, and the Ballistics Research Laboratory of Aberdeen Proving Ground—will conduct similar experiments. The experimental techniques to be employed use, for magnetic field-strength determination, a magnetometer of the free-proton precessional type and, for component determination, an electron-beam magnetometer. With these instruments it will be possible to measure the field strength within 10^{-4} gauss and component directions within a few degrees.

Solar Radiation

One of the fundamental requirements for a better understanding of the processes and characteristics of the earth's atmosphere and, in particular, of the ionospheric regions is a thorough knowledge of the radiation that is received from the sun, both electromagnetic and corpuscular, normal and enhanced. Most atmospheric processes are a direct result of energy absorbed from the sun, yet the governing energy relations have not been sufficiently well established to permit confirmation of many current theories. Thus, experiments planned for the IGY rocket program have, as their objective, measurements of the solar spectrum during flares—a condition of eruption at the sun's surface which leads to greatly increased radiation during periods that may be hours in duration, and which may result in the complete disruption of radio communication at the earth's surface.

Engineer adjusts DOVAP antenna, Fort Churchill, Canada.

IGY DOVAP van arrives at Fort Churchill, Canada. Most rockets that are to be launched at Fort Churchill will carry this device for determining rocket velocity and position during flight.

The Air Force Cambridge Research Center will conduct an experiment which will attempt to extend our knowledge of the solar spectrum to wavelengths below 1000 angstroms and will utilize a spectrograph oriented in the sun's direction by a pointing control, as was previously mentioned. Past flights under the direction of the University of Colorado physics department, the Naval Research Laboratory, and the Air Force Cambridge Research Center have demonstrated the feasibility of this experiment by extending the known solar spectrum to wavelengths approaching 1000 angstroms, a region inaccessible to measurement from the earth's surface because of atmospheric absorption.

The Naval Research Laboratory will also conduct experiments to relate ionospheric D-layer ionization and radio fade-out to flare radiation. To this end, photon counters will be employed for detection of the Lyman alpha spectral line and for x-ray detection in the 1- to 5-angstrom region. Additionally, gamma scintillation counters will be employed for gamma-ray detection during solar flares.

Ionospheric Measurements

One of the more obvious effects of solar radiation on the earth's atmosphere is the formation of a region of ionization, originally called the Kennelly-Heaviside layer, that extends from an altitude perhaps as low as 40 miles to one of at least 300 miles, where the density of the air becomes, from the standpoint of this discussion, negligibly small. Now referred to more commonly as the ionosphere, this region is characterized primarily by an appreciable concentration of free electrons and ions that have been created through the action of solar electromagnetic and corpuscular radiations. In general, somewhat distinct but merging layers are discernible, these having been designated (in ascending order) D, E, F_1, F_2, and G. A distinction between the F_2 and G layers has not been firmly established.

Curiously, perhaps, there is at present relatively little known about the lowest, the D layer, and, as was just noted, little is known about the G layer. Prior to rocket probing, ionospheric investigations were limited to theoretical analysis and to rather extensive indirect measurements made possible by the ionospheric property of reflecting radio waves whose frequencies are less than that which is known as the critical frequency. Rockets have provided direct measurement of the usually more intensely ionized regions (E and F_1) but have not had sufficient capability to attain F_2- or G-layer altitudes. At the same time, the E and F layers have effectively shielded the G layer from radio observation from the ground, and thus it has remained relatively obscure.

The D layer is generally characterized by a low level of ionization as compared with the E layer, so that radio-frequency reflection measurements are not useful. However, it is observed that during solar flares the ionization level in this D region increases sufficiently so that impinging radio-frequency energy, at all but the very lowest frequencies, is strongly absorbed. This seriously restricts or completely prevents communications which depend on the reflective properties of the E or higher layers and, in extreme cases, disrupts even wire communication systems. Until several months ago it was believed that the ionization and the resulting radio-frequency energy-absorption effect were

Typical DOVAP ground receiving station, Fort Churchill, Canada. Here the effect of the rocket's velocity on velocity of propagation of a signal transmitted to rocket and then returned to earth is determined and interpreted to yield rocket velocity and position.

due to hydrogen Lyman alpha radiation and, to some extent, to x-rays—both solar emanations. Recent experiments, however, support theories which attribute D-layer ionization chiefly to x-rays.

Aside from data on the properties of the ionosphere as an entity, knowledge of this region gained through study of the variation of ionic and electron concentration with, for example, altitude, time of day, and geographical location presents an avenue and opportunity for solar studies in areas that are directly relatable to changes in the input of solar energy. It is to be expected, therefore, that an appreciable effort will be made during the IGY rocket research endeavor to conduct many experiments based on ionospheric phenomena.

The earth's auroras are primarily solar- and geomagnetic-dependent ionospheric phenomena. It follows, then, that a better understanding of processes in the auroral zone will permit clarification of present theories relating to both the aurora and the ionosphere. Most experimentation of this kind will be conducted in the northern auroral zone. The areas of particular interest that will receive attention include electron and ion density, the frequency of collision between electrons and other particles, and chemical composition. The Naval Research Laboratory plans to conduct several important experiments for the measurement of these parameters. In one case, a Bennett radio-frequency mass spectrometer, mounted axially in the nose of the rocket, will be employed to determine the chemical composition. Additional, somewhat similar, spectrometers, also mounted in the rocket nose cone but perpendicular to the axis, will be used to determine positive and negative ion composition. The first spectrometer permits neutral gas composition to be determined. The ambient upper-atmosphere gas that diffuses into the spectrometer is ionized, and the positive ions so produced are collected by appropriate electrodes; this makes possible analysis by determination of mass number. After mass number and associated spectra have been determined, concentration ratios can be estimated; this procedure yields information relative to the extent that various gases of the upper atmosphere are mixed, notwithstanding gravity separation. The other spectrometers are employed without ionizing sources and are thus sensitive to ions that diffuse into the instrument. In this manner it will be possible to ascertain the mass number and determine the number density of the free ions existing at the various altitudes.

The Air Force Cambridge Research Center will determine ion number density by an entirely different method. The rocket will be equipped with a special radio-frequency transmitter, which will make possible the determination of the retardation time of a ground-originated, pulsed, radio-frequency signal of frequency near the critical frequency of the E layer. Comparison of this signal with a synchronized radio-frequency pulse of a much higher frequency, also transmitted from the rocket but relatively unretarded by the ionosphere, permits this determination. From these data and the assumption of a static ionization-density condition, the electron density distribution as a function of height may be calculated, on the basis of a ray theory used for the magnetoionic region. In addition, from data obtained by measurement of the changing signal intensity of the rocket-to-earth

transmission, the absorption coefficients as a function of height may be calculated.

The Ballistics Research Laboratory will also measure electron density by a somewhat similar method, which utilizes an aberration of a radio-frequency signal as a source of information. In order to clarify the underlying principle of this experiment, some digression is in order. Most rockets that are to be launched at Fort Churchill will carry a device that is generally not directly associated with their prime experiment but whose functioning will make possible the determination of the rocket's velocity and position during flight. This instrument, to be provided by the Ballistics Research Laboratories, is known as "DOVAP"; the letters are derived from "Doppler," "velocity," and "position." As one might suspect, the Doppler principle is employed—that is, the effect of the rocket's velocity on the velocity of propagation of a signal that is transmitted to the rocket and then returned to earth is determined and interpreted to yield rocket velocity and, subsequently, position.

To return to the experiment for electron density measurement, the effect of the ionized regions on the DOVAP signal is apparently to alter the rocket velocity, making it appear less than was expected. Use is made of this effect by comparing the derived apparent trajectory with an assumed vacuum trajectory, the assumption being very good for the ionospheric regions. The differences noted can be interpreted in terms of equivalent electron number density.

The Naval Research Laboratory will also conduct an interesting experiment whose objectives are to measure electron and ion density, the geomagnetic field, and the collision frequency, with emphasis on geographic and seasonal effects. The method utilizes refractive index measurements related to propagation phenomena. Two harmonically related continuous-wave signals are transmitted from the rocket to ground receiving stations. The ionosphere-affected low-frequency signal is compared with the unaffected higher-frequency signal to acquire the fundamental data. The relationships involving the index of refraction require the ratio of the Doppler shift in free space to that in the medium under investigation. Subsequent reference to the Appleton-Hartree work permits computation of the desired parameters.

Cosmic-Ray Experiments

Cosmic rays are composed of highly energetic particles which enter the earth's atmosphere from space. Their presence was first detected by observing a minute degree of ionization in the dense air at the earth's surface. Gradual elimination of various possibilities for explanation of the ionization led to the concept of charged particles arriving from space. More recently, through balloon and rocket exploration, the particles have been identified as being primarily protons (hydrogen nuclei), alpha particles (helium nuclei), and heavier nuclei, with the protons greatly predominating. The energy possessed by individual particles is measured in units of billions of electron volts, a level attainable today only by the largest man-made accelerators.

Penetration of the original particles, called "primaries," into the atmosphere and the consequent collision with atmospheric gas particles results in a form of secondary emission. This secondary radiation contains all the subatomic particles known—mesons, electrons, positrons, hyperons, neutrons, and protons. Since the primary radiation consists of charged particles, their paths or trajectories in the neighborhood of the earth are influenced to a substantial degree by the geomagnetic field. Particles entering, roughly, along the earth's axis (along the magnetic-field axis) are relatively unaffected, while those entering perpendicular to the axis exhibit a maximum effect. Consequently, a strong latitude effect can be observed, which can be quite useful for determining the energy distribution of the primary particles.

In general, only particles of the highest energy can reach the top of the atmosphere at the equator; these are described as magnetically rigid. As the latitude increases, more of the less energetic particles can enter.

The University of Iowa physics department will conduct many experiments on a synoptic basis to make possible a qualitative and quantitative study of the soft auroral radiation in the auroral zone. Specific objectives include determination of the nature and energy distribution of the radiation and acquisition of information regarding latitude distribution and information which will permit correlation of the soft radiation with auroras and other geographic and solar phenomena. The experimental technique employs appropriately oriented arrays of Geiger counters, scintillating crystals, and other radiation detectors. The experiment will be conducted from the ground and from shipboard at many latitudes, in both the arctic and antarctic.

The same organization will perform related experiments for the purpose of determining the fluctuations of total cosmic-ray intensity above the atmosphere in far northerly and southerly latitudes. Correlation of these variations with sea-level measurements, with determinations made from mountaintop experiments, with balloon-flight re-

sults of other workers, and with a measurement of the gross latitude variation of total cosmic-ray intensity above the atmosphere will provide information regarding north-south hemispherical symmetry of arrival of cosmic rays. Again, Geiger-counter devices will be employed.

Analysis and Publication of Data

The ultimate value of the rocket experiments that have been described, and of the many other programs that constitute the over-all effort of the IGY, will be determined largely by how effectively the acquired data are used. First, however, must come the task of reducing, analyzing, distributing, and publishing the data—a task which is very large in comparison with the extent of the experimental program. Although a rocket flight may afford an information-producing life of only several minutes, masses of data of varying consequence are recorded. Some of this may be set aside in favor of portions which appear to be of greater consequence; however, all must be studied and processed to make possible the necessary selection, and all should be preserved to avoid loss of data that may later prove to be meaningful.

Clearly, effective use of the information cannot result without extensive distribution and publication. Present plans contemplate the publication of data, by the originating agency, in suitable technical journals which will afford desirable world-wide circulation. Further, to assure dissemination of the scientific information acquired, various data centers are to be established, on a world-wide basis, to serve as permanent repositories for data relative to each discipline. In addition, a number of interdisciplinary centers are planned. Thus, there will be stored, for study and perusal by present and future scientists, a vast amount of data from "the greatest assault in history on the secrets of the earth and its atmosphere" (*6*).

References and Notes

1. J. Kaplan, University of California, Los Angeles, chairman.
2. J. A. Van Allen, University of Iowa, chairman.
3. I wish to acknowledge the very valuable assistance given me in the preparation of this article by my several colleagues on the Special Committee for the International Geophysical Year and by many members of the Technical Panel on Rocketry and the Upper Atmosphere Rocket Research Panel.
4. F. L. Whipple, Harvard University, chairman.
5. F. L. Bartman *et al.*, "Upper air density and temperature by the falling sphere method," *J. Appl. Phys.* **27** (July, 1956); J. A. Van Allen, "Direct detection of auroral radiation with rocket equipment," *Proc. Natl. Acad. Sci. U.S.* **43**, 57 (1957); L. J. Cahill and J. A. Van Allen, "High altitude measurement of the earth's magnetic field with a proton precessional magnetometer," *J. Geophys. Research* **61**, 547 (1956); H. S. Sicinski, N. W. Spencer, W. G. Dow, "Rocket measurements of upper atmosphere ambient temperature and pressure in the 30- to 75-kilometer region," *J. Appl. Phys.* **25**, 161 (1954); W. G. Stroud, W. Nordberg, J. R. Walsh, "Atmospheric temperatures and winds between 30 and 80 kilometers," *J. Geophys. Research* **61**, No. 1 (1956); The Rocket Panel, "Pressures, densities, and temperatures in the upper atmosphere," *Phys. Rev.* **88**, 1027 (1952); H. E. Newell, *High Altitude Rocket Research* (Academic Press, New York, 1953); R. A. Minzner, M. Dubin, E. W. Beth, "Ambient temperature determinations from yawing rockets in the presence of winds," in *Rocket Exploration of the Upper Atmosphere* (Pergamon, London, 1956); J. Pressman *et al.*, "A synthetic atmospheric chemi-luminescence caused by the release of NO at 106 km," *J. Chem. Phys.* **25**, 187 (1956); L. M. Jones *et al.*, "The Nike-Cajun sounding rocket," *Jet Propulsion* **27**, No. 3 (1957); J. W. Townsend and R. M. Slavin, "Aerobee-Hi development program," *Jet Propulsion* **27**, No. 3 (1957); R. Horowitz and H. E. LaGow, "Upper air pressure and density measurements from 90 to 220 km with the Viking 7 rocket," *J. Geophys. Research* **62**, 57 (1957); J. E. Jackson, J. A. Kane, J. C. Seddon, "Ionosphere electron density measurements with the Navy Aerobee-Hi rocket," *J. Geophys. Research* **61**, 749 (1956).
6. L. V. Berkner, president, International Council of Scientific Unions.

Sadi Carnot

MILTON KERKER

Dr. Kerker teaches chemical thermodynamics and the history of science at Clarkson College of Technology, Potsdam, New York, where he is professor of chemistry. His research in light scattering by colloidal particles is supported by the U.S. Atomic Energy Commission. He received his training in chemistry at Columbia University and in 1952–53 studied history of science at Cornell University under the sponsorship of a Ford Foundation faculty fellowship.

"So shall thou instant reach the realm assigned
In wondrous ships, self moved, instinct with mind."
—Homer's *Odyssey* (translated by Pope).

I WENT to every book shop I could think of, asking for the *Puissance motrice du feu,* by Carnot. 'Caino? Je ne connais pas cet auteur.' With much difficulty I tried to explain that it was 'r' not 'i' I meant. 'Ah, Ca-rrr-not! Oui, voici son ouvrage,' producing a volume on some social question by Hippolyte Carnot; but the *Puissance motrice du feu* was quite unknown" (*1*).

Thus, in 1845, did the 21-year-old William Thomson (Fig. 1) (who was later to become Lord Kelvin) search in vain for the *Reflections on the Motive Power of Heat and on the Machines Adapted to Develop This Power,* by Nicholas Leonard Sadi Carnot (Fig. 2). "Quite unknown"—such was the fate of the great memoir which laid the foundations of thermodynamics. And such was the fate of its author, one of that select fraternity of genius who, within the span of a tragically short life, was able to explore with marvelous insight a whole new province of thought.

Soldiers and Scientists

Sadi Carnot was born 1 June 1796 in the palace of Luxembourg in Paris, where his father, Lazare Nicholas Marguerite (*2*), then lived as a member of the Directory. The elder Carnot had already established his niche in the history of science when, as a young officer before the outbreak of the revolution, he had published a number of important works in mathematics and engineering. A meteoric rise during the revolution led to his being dispatched to direct military operations at the northern frontier where he turned impending disaster into glorious victory. Returning to Paris, he participated in the top echelons of revolutionary politics but not skillfully enough to avoid exile to Switzerland in 1797. He returned to France in 1799 to become Napoleon's minister of war, to serve as a member of the tribunate, and ultimately to occupy a seat in the Academy of Sciences. After Waterloo he was again forced into exile in Germany, where he published sonnets and scientific works until his death in 1823, at the age of 70.

Young Sadi, reared in such an atmosphere of grandeur, could not fail to exhibit a nobility of character illustrated in the following anecdote, related by his younger brother, Hippolyte (*3*).

"When the minister went to Malmaison to work with the First Consul, he often took with him his son, then about four years old, to stay with Madame Bonaparte, who was greatly attached to him.

"She was one day with some other ladies in a small boat on a pond, the ladies rowing the boat themselves, when Bonaparte, unexpectedly appearing, amused himself by picking up stones and throwing them near the boat, spattering water on the fresh toilets of the rowers. The ladies dared not manifest their displeasure, but the little Sadi, after having looked on at the affair for some time, suddenly placed himself boldly before the conquerer of Marengo, and threatening him with his fist, he cried, 'Beast of a First Consul, will you stop tormenting those ladies.'

"Bonaparte, at this unexpected attack, stopped and looked in astonishment at the child. Then he was seized with a fit of laughter in which all the spectators of the scene joined."

Carnot prepared to follow in his father's footsteps by entering the Ecole Polytechnique in 1812. This school had been founded by the National Convention in 1794 as a protest against the exclusive concern with literacy and abstract studies in places of higher education but at this time was devoted largely to instruction of recruits for civil and military engineering. These were stirring days in France, and that the students did not live in an ivory tower is attested to by the following petition written by Carnot and addressed to the Emperor in December 1813.

"Sir: The country needs all its defenders. The pupils of the Ecole Polytechnique, faithful to their motto, ask to be permitted to hasten to the frontiers to share the glory of the brave men who are consecrating themselves to the safety of France. The battalion, proud of having contributed to the defeat of the enemy, will return to school to cultivate the sciences and prepare for new services."

The request was granted, and in March 1814 the students took part in the military exploits of Vincennes.

Carnot left the Ecole Polytechnique in October 1814 with a commission in the engineer corps and went to the artillery school at Metz, where he served as an instructor with the rank of cadet sublieutenant. With the Bourbons reestablished after Waterloo and his father proscribed, Carnot was subjected to the petty inequities so often visited upon an officer out of favor. He was sent successively into many trying places to pursue his vocation of engineer, to count bricks, to repair walls, and to draw plans destined to be hidden in portfolios. He performed these duties conscientiously and without hope of the promotion which his name now impeded. This impasse was broken in 1819 when he succeeded in procuring an appointment to the new general staff corps in Paris. This provided him with the leisure and atmosphere to pursue the studious life to which he was to devote himself henceforth.

His intellect was insatiable and led him into many branches of knowledge. Music was almost a passion with him, and not content merely to play well on the violin, Sadi delved at great length into musical theory. He diligently followed the public lectures at the Sorbonne, the Ecole des Mines, and the Bibliotheque of the type so popular both in France and England at this time. He visited factories to familiarize himself with manufacturing processes and cultivated with equal ardor mathematics, physical science, natural history, and political economy. He practised gymnastics, fencing, swimming, dancing, and skating with enthusiasm and was an expert in all these amusements.

Fig. 2. Sadi Carnot at the age of 17, from a portrait by Bailly, 1813.

Yet, despite his accomplishments, he was naturally reserved, and even his intimates knew very little about his work. His own brother, with whom he lived at the time he wrote his great memoir on heat, was hardly aware of the work in progress. This picture of Carnot's outward reserve, coupled with his intense inner life, is illustrated by another anecdote related by his brother. It was during the insurrection of 1830. "A horseman preceding a company, and who was evidently intoxicated, passed along the street at a gallop, brandishing his sabre and striking down the passersby. Sadi darted forward, cleverly avoided the weapon of the soldier, seized him by the leg, threw him to the earth and laid him in the gutter, then continued on his way to escape from the cheers of the crowd, amazed at this daring deed."

In 1828 Carnot left the army in order to devote full time to his studies. On 24 August 1832, he was carried off, aged 36, in the full vigor of life, by an attack of cholera. Many of his copybooks, filled with memoranda, were burned with his personal effects, as was the custom for victims of cholera.

Fig. 1. William Thomson, 1846.

Puissance Motrice du Feu

Carnot's only publication (*4*), the 128-page memoir sought by Thomson in the bookstalls of Paris, appeared in a limited edition in 1824 when he was 28 years old. The problem to which he addressed himself was an analysis of the factors that determine the production of mechanical energy from heat in the steam engine and heat engines in general. The youthful officer pointed out that "already the steam-engine works our mines, impels our ships, excavates our ports and our rivers, forges iron, fashions wood, grinds grains, spins and weaves our clothes, transports the heaviest burdens, etc. It appears that it must some day serve as a universal motor, and be substituted for animal power, waterfalls, and air currents."

Yet, there was at the time no theory which could give direction to its continued improvement. Questions had already been raised for which no answers had been forthcoming. How was the work developed by the engine related to the heat supplied? Was there an upper limit to this work, and what condition could lead to its release? Was water the best material to use, or might not some other liquid such as alcohol provide a more effective medium? Might not a gas such as air be more advantageous than a condensable vapor?

Carnot pointed out that a necessary condition for obtaining work from a heat engine is the passage of heat from a body at a high temperature—the boiler—to another body in which the temperature is lower—the condenser. In fact, an analogy could be set up between the production of work in the heat engine by the passage of heat through a difference of temperature and the work produced in a water wheel by the passage of water through a difference of gravitational potential (Fig. 3).

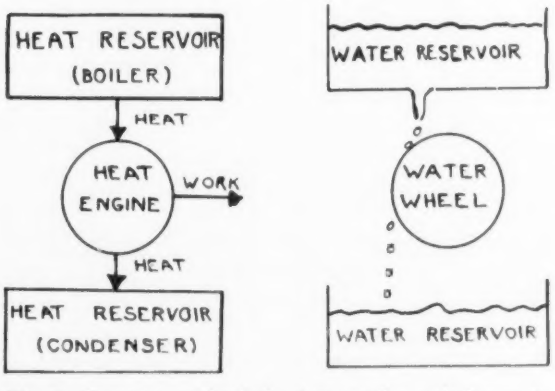


Fig. 3. Carnot conceived of a heat engine as being analogous to a water wheel. In the one case, work results from the passage of heat between two reservoirs and, in the other, from the passage of water.

This point of view was not particularly original with Carnot. However, his father, in a work published before the revolution, had enlarged the theory of water-driven machines by demonstrating that the machine works with highest efficiency when the driving liquid transfers its motion to the driven wheel in insensibly small steps. Carnot sought the analogous condition in the heat engine that would lead to its operation at maximum efficiency. It was the discovery of this condition, the *reversible* process, that provided the point of departure for his work.

The condition of the maximum production of work was that there should not occur any change of temperature in the bodies employed which was not due to a change of volume, eliminating such effects as friction, turbulence, and direct conduction of heat through the parts of the engine. Such direct transference of heat was equivalent to wasting a difference of temperature which might have been utilized to produce motive power. This condition of maximum efficiency was characterized by its *reversibility*. If the reverse of such a process were carried through, all the effects would be of the same magnitude but reversed in direction.

In order to facilitate his analysis, Carnot devised a number of simple sequences of operation by which a heat engine might produce motive power. The most famous of these is now known as the Carnot cycle. A gas is expanded while it is in contact with a heat reservoir from which it absorbs a quantity of heat sufficient to maintain its temperature constant. A second expansion is carried out while the gas is insulated, resulting in a temperature drop. The gas is then compressed while it is in contact with a second heat reservoir, giving heat up to this reservoir in order to maintain constant temperature. The final step is a second compression, while the gas is insulated, to restore the initial temperature and, if necessary, a final constant temperature compression or expansion to restore the original pressure (Figs. 4 and 5).

At the end of the cycle the gas has been restored to its original condition. Since the cycle was carried out reversibly, the work produced for any stage of the process is a maximum. Carnot considered that the mechanical work of such an engine was produced merely by the transportation of heat by the gas from the warmer to the cooler heat reservoir.

Carnot proposed the possibility of coupling two reversible heat engines utilizing different working substances in order to compare their efficiencies in producing work. While the first engine was to be operated in the usual manner between two heat reservoirs, the work it produced would be used to drive the second engine in the reverse direction—

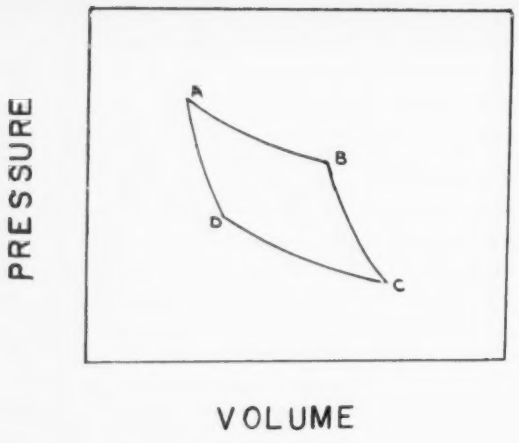


Fig. 4. Graphical representation of the behavior of a gas during a Carnot cycle. The pressure and volume of the gas change along the line *AB* while the gas is being expanded in contact with the upper heat reservoir (boiler), and along *CD* when it is compressed while in contact with the lower heat reservoir (condenser). *BC* and *DA* represent the paths of the gas during the insulated expansion and compression. The area of the figure, *ABCD*, gives the work done by the gas during the cycle.

that is, to transfer heat from the cool to the warm reservoir (Fig. 6).

Carnot reasoned that, if the first engine operated with greater efficiency, the second engine would transfer more heat, with the result that there would be a net transfer of heat from the reservoir at the lower temperature to that at the higher temperature. Since each engine operates through a cycle in which the original conditions within the engine are restored, this transfer of heat to the higher temperature would be unaccompanied by any compensating effect. This heat could then be utilized to drive another engine, resulting in a perpetual motion. Since such a possibility had long been denied, Carnot reasoned that the initial assumption of unequal efficiencies among reversible heat engines must have been erroneous, and he concluded that all reversible engines operating between the same temperatures must have the same efficiency, regardless of the medium utilized as the carrier of the heat. Hence, it was the reversible operation of the engine, not the use of steam, alcohol, or anything else, that determined its efficiency in producing mechanical work by the fall of heat through a difference of temperature.

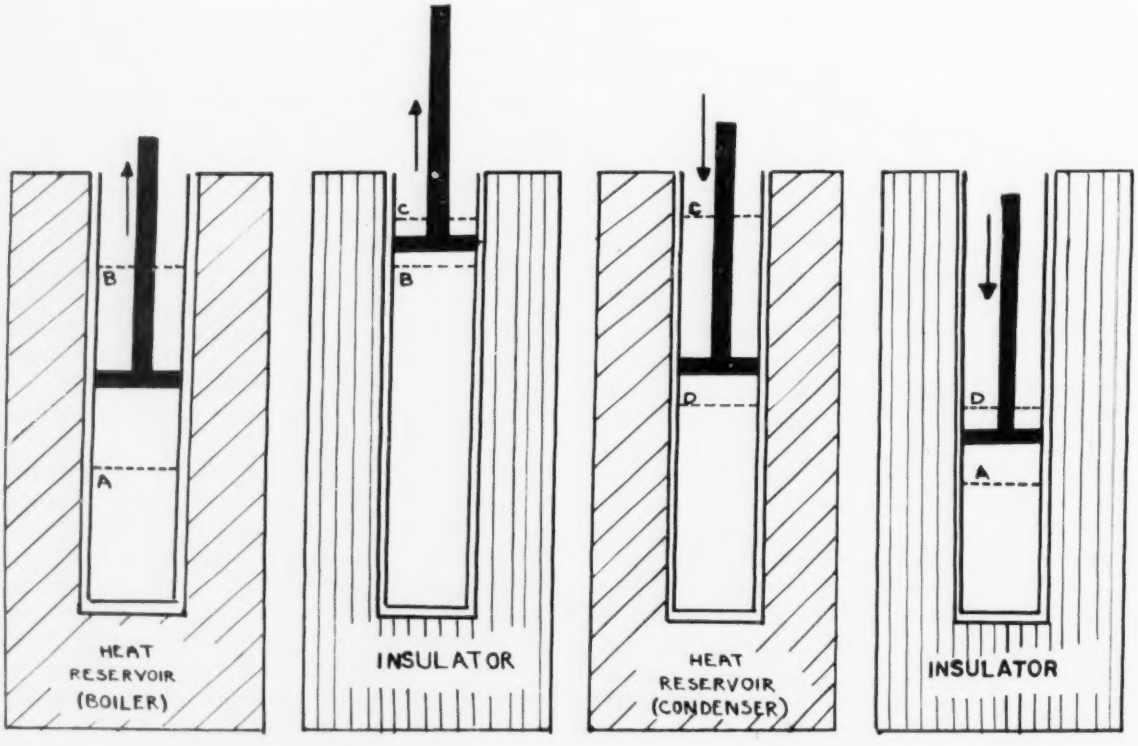


Fig. 5. This is a physical representation of the Carnot cycle. The gas is contained in a cylinder fitted with a piston and surrounded by either a heat reservoir or an insulator. *A*, *B*, *C*, and *D* represent the volume of the gas at the corresponding points on Fig. 4. Thus, from left to right, the four representations here give the physical condition of the gas at some point along the lines *AB*, *BC*, *CD*, and *DA* of Fig. 4.

Carnot also concluded that, for a given quantity of heat transferred, the work produced was greater, the greater the difference of temperature between boiler and condenser. Furthermore, for the same difference of temperature, the engine would operate more efficiently, the lower these temperatures.

Although he was not able to derive a general formula for the relation between the maximum work which could be produced and the operating temperatures, the principles to be considered in the design of heat engines were now clear. Maintain the greatest possible temperature difference between the boiler and condenser. If faced with the possibility of a choice of equal temperature intervals, select that one lowest on the temperature scale. The actual working medium is unimportant from the point of view of thermodynamic efficiency, except as its properties affect the working temperatures. Seek to operate as closely to the reversible conditions as practical.

Modern students of thermodynamics are well aware that, in the heat engine, work appears as the result of the conversion of some of the heat being transferred and that not all of the heat which leaves the boiler finds its way into the condenser. There is a loss of heat equivalent to the work produced in accordance with the general principle now known as the first law of thermodynamics.

It is at this point that Carnot's analogy with the water wheel breaks down. In the water wheel, the amount of water leaving at the lower level is equal to the amount entering at the upper level. In his treatment, Carnot considered that work appeared as the result of the fall of heat through a difference of temperature. There was no conversion of heat —rather, there was a conservation of heat. His result, then, was completely erroneous insofar as it was concerned with the question "How is work obtained from heat?" If this is so, why regard his work as a masterpiece of scientific discovery? The answer amounts to the fact that Carnot was not asking this question. Rather, he was concerned with asserting the conditions under which the maximum conversion of heat into work may take place. His results in this area still stand, and because the reasoning which led to them in no way involves the question of the conversion of heat into work, that reasoning also remains valid. However, confusion did result in the minds of some of the scientists who came later, because they were unable to disentangle those of Carnot's statements which were valid from those which were not.

Kelvin's Dilemma: Carnot's or Joule's Principle

Ten years passed without Carnot's book finding the least echo. In 1834 the French civil engineer,

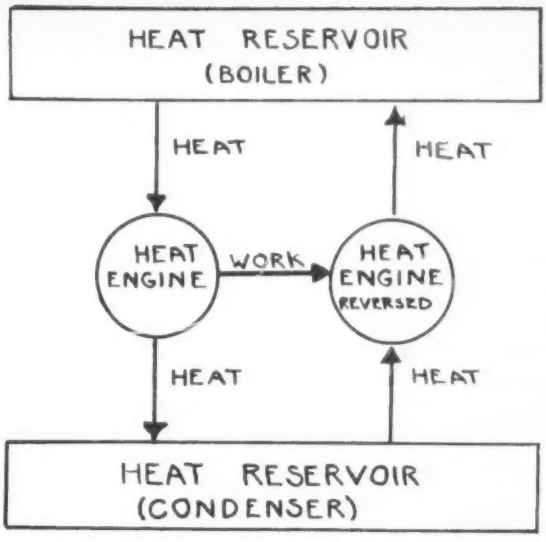


Fig. 6. Coupled heat engines. The work obtained from the heat engine is used to operate the reversed heat engine (refrigerator), transferring heat from the condenser to the boiler.

Benoit Pierre Emile Clapeyron (*5*), a classmate of Carnot's at the Ecole Polytechnique, published a paper in which he described Carnot's ideas. He translated Carnot's verbal analysis into the symbolism of the calculus and represented the Carnot cycle graphically by means of the Watt indicator diagram, familiar to engineers. Carnot's theory was thereafter tacitly accepted by all practical engineers.

By the mid-1840's, the English physicist, James Prescott Joule, and the German physician, Joseph Mayer, had established the principle of the conservation of energy. Joule recognized that in his memoir Carnot had done violence to this principle by likening the flow of heat to that of water, and he concluded that this vitiated Carnot's theory. In 1845 he wrote: "It is the opinion of many philosophers that the mechanical power of heat arises simply from the passage of heat from a hot to a cold body, no heat being necessarily lost during the transfer. This view has been adopted by Mr. E. Clapeyron . . . [who] agrees with Mr. Carnot. . . . I conceive that this theory, however ingenious, is opposed to the recognized principles of philosophy because it leads to the conclusion that vis viva [energy] may be destroyed by an improper disposition of the apparatus. Believing that the power to destroy belongs to the Creator alone . . . any theory which . . . demands the annihilation of force is necessarily erroneous" (*6*).

After graduating from Cambridge in 1845, William Thomson spent the summer working in Henri Victor Regnault's famous laboratory in Paris. Reg-

nault was engaged in a mammoth experimental project, subsidized by the French government, to acquire more accurate thermal data pertinent to the design of steam engines. It was on this occasion that Thomson became acquainted with Carnot's work from Clapeyron's paper. Thomson's interest in the problem of heat was revived in 1847 when he first made the acquaintance of Joule. "I can never forget the British Association [meeting] at Oxford in 1847, when in one of the sections I heard a paper read by a very unassuming young man, who betrayed no consciousness in his manner that he had a great idea to unfold. I at first thought it could not be true, because it was different from Carnot's theory, and immediately after reading the paper, I had a few words with the author, James Joule, which was the beginning of our forty years acquaintance and friendship" (*7*).

For the next few years, Thomson remained in a quandary over what appeared to be a contradiction between the theories of Carnot and Joule. He himself had found Carnot's work extremely fruitful. It led him to the establishment of an absolute temperature scale (*8*), an exceedingly attractive possibility for one who had been so close to the practical problems of thermometry in Regnault's laboratory. Furthermore, his brother, James Thomson, using Carnot's reasoning, predicted that, since ice has a greater specific volume than liquid water at the freezing point, increase of pressure should lower the freezing point. William Thomson verified this experimentally, obtaining values for the amount of lowering in close agreement with the predicted figures (*9*). Yet he knew that Joule's work was impeccable; hence, he could only suspend judgment until further experiments would provide either a "verification of Carnot's axiom—or an entirely new basis of the Theory of Heat" of Joule (*10*).

However, clarification did not depend on new experiments, as Thomson proposed, but on a careful critique of the work already available. The dilemma was resolved in 1851 simultaneously by the German physicist, Rudolph Clausius, and Thomson (*11*). They each recognized that Joule's and Carnot's principles were not inconsistent with each other. Clausius pointed out that, although Carnot had implied that no heat was lost during the heat engine cycle, this statement was not involved in the reasoning related to the efficiency of the heat engine. It entered into some subsidiary consequences that Carnot had considered and "it seems, therefore, to be theoretically admissible to retain the first and the really essential part of Carnot's assumptions." Clausius succeeded in casting Carnot's and Joule's principles into the general form now known as the first two laws of thermodynamics. His succinct formulation of these is the famous statement that "the energy of the world is constant; the entropy tends to a maximum."

Mechanical Equivalent of Heat

When Hippolyte Carnot conveyed the manuscript copy of the *Puissance Motrice du Feu* to the French Academy of Sciences in 1878, he accompanied it with some unedited fragments from Carnot's notebooks. These indicated that before his death, Carnot himself had taken up the problem of the conservation of energy and had arrived at precisely the same conclusions as Mayer and Joule. He wrote: "Heat is simply motive power, or rather motion which has changed form. It is a movement among the particles of bodies. Wherever there is destruction of motive power, there is, at the same time, production of heat in quantity exactly proportional to the quantity of motive power destroyed. Reciprocally, wherever there is destruction of heat, there is production of motive power.

"We can then establish the general proposition that motive power is, in quantity, invariable in nature; that it is, correctly speaking, never either produced or destroyed. It is true that it changes form; that is, it produces sometimes one sort of motion, sometimes another, but it is never annihilated."

No modern formulation of the first law of thermodynamics can improve upon this statement. Carnot actually calculated the mechanical equivalent of heat and suggested experiments in support of his conclusions, some of which were similar to those that Joule was to carry out later. The entire structure of thermodynamics was foreshadowed in his work. Had he lived beyond a mere 36 years, the history of science would have certainly been different.

Repercussions: Caloric and Entropy

Our interpretation of Carnot's memoir is one that most physicists and historians of science would agree with. However, there have been objections to this point of view (*12*). Some have suggested that Carnot's treatment of heat was so akin to the concept of entropy formulated by Clausius that perhaps this was what he had in mind, and that the *Puissance Motrice du Feu* was actually consistent with the first law of thermodynamics as well as being strikingly modern in its treatment of matters dealt with by the second law.

In the article on heat written for the 11th edition of the *Encyclopedia Britannica* in 1910, the British physicist H. C. Callendar claimed that in

his account of the heat engine cycle, Clapeyron had made some errors which Carnot himself had avoided. Specifically, Callendar said that, unlike Clapeyron, Carnot had not assumed that the same amount of heat is disengaged from the gas while it is in contact with the condenser as is added at the boiler. Since Kelvin and Clausius learned of Carnot's work from Clapeyron's paper, Callendar proposed that they had incorrectly attributed this error to Carnot.

In 1919 A. C. Lunn, of the University of Chicago, pointed out "that in some ways Carnot's 'caloric' shows distinct resemblance to entropy rather than to thermal energy. Detailed examination shows that most of the propositions of Carnot's essay . . . though so often called erroneous and even meaningless by commentators, have a meaning and are correct if 'caloric' is taken to mean entropy." In fact by following a point of view suggested to him by Carnot's memoir, Lunn was led to a reformulation of thermodynamics in a more symmetric form.

The latest step in this direction was taken in 1954 by V. K. LaMer, of Columbia University, who proposed that not only could Carnot's work be made meaningful by interpreting his "caloric" as entropy but that Carnot himself had something of this sort in mind. LaMer pointed out that, although the words *chaleur* and *caloric* are indiscriminately translated into English as *heat*, Carnot distinguished between the two, using *chaleur* in the sense of thermal energy and *caloric* in the sense of entropy.

This point of view has been vigorously attacked by T. S. Kuhn, of Harvard University, who insists that there is no fundamental difference between Carnot's and Clapeyron's treatment of the heat engine cycle and denies that Carnot did distinguish between the use of the terms *caloric* and *chaleur*. In support of his contention that Carnot used these words in the sense accepted by his contemporaries, he quotes Carnot's footnote which says: "It is considered unnecessary to explain here what is quantity of caloric or quantity of heat for we employ these two expressions indifferently, or to describe how we measure these quantities by the calorimeter. Nor will we explain what is meant by latent heat, degree of temperature, specific heat, etc. The reader should be familiarized with these terms through the study of the elementary treatises of physics or of chemistry."

Certainly one can agree with the French physicist, Leon Brillouin, when he says: "It is remarkable that the simple substitution of *entropy* for the term *caloric* renders the memoir subtilely modern." But is this substitution justified? Perhaps there is more of a philological problem here than historians of science have heretofore assumed. In any event, whether Carnot's prescience was implicit or explicit, his achievement was tremendous. The *Puissance Motrice du Feu* will always rank as one of the classics of science, and Sadi Carnot will always be remembered as the grand architect of thermodynamics.

References and Notes

1. W. Thomson, "On the dissipation of energy," *Fortnightly Review* (Mar. 1892).
2. Lazare Carnot's life and work are described by C. B. Boyer, "The great Carnot," *Mathematics Teacher* **49**, 7 (1956). A bibliography is included. Other illustrious members of the Carnot family include a younger son, Lazare Hippolyte, a republican statesman. One of the latter's sons, Marie Adolphe, was a chemist and a member of the Academie des Sciences. The other son, named for his Uncle Sadi, served as fourth president of the Third French Republic from 1887 until his assassination by an anarchist in 1894.
3. H. Carnot, "Life of Sadi Carnot," included as introductory section in R. H. Thurston's translation *Reflections on the Motive Power of Heat* (New York and London, 1897).
4. S. Carnot, *Reflexions sur la Puissance Motrice du Feu et sur les Machines Propres a Developper Cette Puissance* (Paris, 1824). The two English translations are by R. H. Thurston (*3*) and by W. F. Magie in *The Second Law of Thermodynamics* (New York, 1899). A French paperback facsimile of an 1878 edition is now available with the imprimerie of A. Blanchard, Paris, 1953. This includes some of the posthumous notes.
5. B. P. S. Clapeyron, "Memoir on the motive power of heat," *J. école polytech. (Paris)* **14**, 153 (1834).
6. J. P. Joule, "On the changes of temperature produced by the rarefaction and condensation of air," *Phil. Mag.* **26**, 369 (1845).
7. Quoted by A. Gray, *Lord Kelvin* (London, 1908), p. 86, from an address delivered on the occasion of the unveiling of a statue of Joule, in Manchester Town Hall, on 7 Dec. 1893.
8. W. Thomson, "On an absolute thermometric scale founded on Carnot's theory of the motive power of heat, and calculated from Regnault's observations," *Phil. Mag.* (Oct. 1848).
9. J. Thomson, "Theoretical considerations on the effect of pressure in lowering the freezing point of water," *Trans. Roy. Soc. Edinburgh* **16** (1849). W. Thomson, "The effect of pressure in lowering the freezing point of water experimentally demonstrated," *Phil. Mag.* **37** (1850).
10. W. Thomson, "An account of Carnot's theory of the motive power of heat," *Trans. Roy. Soc. Edinburgh* **16** (1849).
11. R. Clausius, "On the motive power of heat," *Poggendorffs Ann.* **79**, 376, 500 (1850). W. Thomson "On the dynamical theory of heat," *Trans. Roy. Soc. Edinburgh* (Mar. 1851).
12. The key references for this section are as follows: H. L. Callendar, "The caloric theory of heat and Carnot's principle," *Proc. Phys. Soc. (London)* **23**, 153 (1911); A. C. Lunn, "The measurement of heat and the scope of Carnot's principle," *Phys. Rev.* **14**, 1 (1919); V. K. LaMer, "Some current misinterpretations of N. L. Sadi Carnot's memoir and cycle," *Am. J. Phys.* **22**, 20 (1954); **23**, 95 (1955); T. S. Kuhn, "Carnot's version of 'Carnot's Cycle,'" *ibid.* **23**, 90, 387 (1955); M. A. Hirshfeld, "On 'Some current misinterpretations of Carnot's memoir,'" *ibid.* **23**, 103 (1955).

American Medical Mission to the Soviet Union

JOHN R. PAUL

Dr. Paul is a graduate of Princeton University and of the Johns Hopkins Medical School. He has been on the faculty of the Yale University School of Medicine since 1928, where he is now head of the section of preventive medicine. He is a physician and an epidemiologist. His work in epidemiology has taken him on a number of foreign assignments—to North Africa, to Europe, and to tropical and arctic areas—for the study of disease under widely differing conditions. During World War II he served as consultant to the Secretary of War on assignments of this kind. His particular interest has been the field of virus diseases, notably poliomyelitis, and in this connection he is currently serving as a member of the Expert Committee on Viruses of the U.N. World Health Organization.

MISSIONS for the exchange of scientific and technical information between the United States and the Soviet Union were in vogue during World War II. But with the fall of the Iron Curtain in 1945, they were interrupted for a dozen years, to be resumed as the result of a temporary change in political climate, touched off by the Geneva conferences of 1955. First there were the farmers' missions, in 1955; these were followed by a number of others, including missions of atomic physicists and churchmen, and, in 1956, two missions on medical subjects. The first of these medical missions visited the Soviet Union during February and March 1956 (*1*). It was largely concerned with the fields of microbiology, epidemiology, the control of infectious diseases, and cancer research.

This mission was an exchange affair in that a group of four Soviet medical scientists (microbiologists) (*2*) first visited this country in January 1956 and the United States return mission followed immediately, having been organized and dispatched so promptly by the U.S. Department of Health, Education, and Welfare, acting at the request of the State Department, that we arrived in Moscow even before some of our Russian hosts had returned from the United States.

Within the Soviet Union we were greeted cordially by official guides and hosts, who shepherded us about in an atmosphere which was serious but not unfriendly. There was not exactly a feeling of suspicion, but there was a constant reminder that those around us were consumed with curiosity to learn what medical scientists from the United States were going to be like and how we were going to regard them. Uppermost in the minds of some of them was the recent claim, from an unknown source, which had been widely publicized in Russia, that "America has nothing to learn from Soviet medicine." Was this going to be our attitude?

It happened, by chance, that our visit to Russia coincided with certain important events in the history of the Soviet Union. The 20th congress of the Communist Party of the Soviet Union had just terminated, in February 1956; the sixth 5-year plan had been presented and accepted; the anti-Stalin movement had begun. Such events could not help but have an effect on the scientists whom we met. They, too, shared in the hope that a new era had begun and that they were actually emerging from a period marked by tyranny and oppression. Stalin was not mentioned by name, but some of his portraits in the research institutes were coming down. Certainly the political climate was milder than the one I had experienced in 1949 on a previous trip behind the Iron Curtain.

Scientific Research and Higher Education

Scientists in the medical research institutes were particularly hopeful because of the government's recent expression of sympathy with science, especially with applied science and its accomplishments. Indeed, the delegates to the recent congress had publicly thanked the scientists of the Soviet Union for their work. Furthermore, the medical profession had been singled out and called on to intensify its future efforts in the fields of curative and preventive medicine, and the program was outlined in the new 5-year plan for work in the medical sciences (*3*). This meant special support.

Main auditorium, with stage, University of Moscow, visited by the first U.S. medical mission to the U.S.S.R. in February and March 1956. [Courtesy K. F. Meyer]

Bulganin, in his speech, had also noted that the present situation was one in which there had been too much secrecy about the work and too much concentration of research institutes and their corresponding personnel within the large cities of Moscow and Leningrad. The plan also intimated that there was to be expansion and decentralization.

This government interest in the ideals and potentialities of science and scientists is part of the Soviet worship of modern technology. Five-year plans for work in these scientific fields are not only expressions of purpose; they seem to be almost religious dedications.

Actually, the position of the scientist in the Soviet Union, be he medically oriented or otherwise, is a very important one. I am told that the English word *science* is directly translatable into Russian as *Nauka*. But the English word for scientist has no direct equivalent; in Russian it comes out *Uchonoy*, which really means "learned one." Armed with this serious title, the scientist who achieves distinction may reach a position of no mean stature in the national scale. Professionally, many of them hold at least two posts, those of head of a laboratory in a research institute and occupant of a "chair" on a medical faculty. Both positions pay full salaries for a 6-hour day. Membership in the Academy of Medical Sciences is taken very seriously, and it also carries a financial emolument. In terms of actual remuneration, let us say that a young woman starts life as a biochemical technician, at the bottom of the ladder, at a salary of 1000 rubles a month. If, subsequently, she applies for and obtains the degree of candidate of medical science, the salary is doubled; with the degree of doctor, it is doubled again. She is now earning 4000 rubles a month, and if she does some writing or translating and is fortunate enough to be elected to the Academy of Medical Sciences, besides, a monthly salary of 10,000 rubles is possible. This compares favorably with the top salaries in other walks of life. To achieve these ends, the would-be scientist must conform to the plans of the research or educational institute to which he or she may be assigned. Achievements are *according to plan*, defects are remedied by subsequent plans.

Education has become another object of veneration and worship in the Soviet Union. In a nation where, prior to the revolution of 1917, the extent of illiteracy was appalling, prodigious efforts have been made to rectify the situation. These efforts have been largely concerned with secondary schools, but higher education has been expanded and glorified. Our liaison officer wore, at all times, the badge which indicated that he was a graduate of the University of Moscow, and when the time came, he showed us the new buildings of that university with great pride. These immense structures, built in 1953, dominate the flat landscape on the outskirts of the city like a great shrine, which can be seen for miles. If the university was built partly for show, it fulfills this purpose well.

K. M. Bykov (left), member of the Soviet Academy of Science, and M. B. Shimkin (right) of the U.S. National Cancer Institute, in front of the commemorative plaque in the hall of the laboratory and home of the late I. Pavlov at Koltushi, near Leningrad. A translation of the inscription reads: "From 1933 to 1936, here lived and worked Academician I. P. Pavlov, the founder of this Bio Station, discoverer of conditioned reflexes, and the initiator of genetic studies of higher nervous action." [Courtesy K. F. Meyer]

With a student body of some 20,000, it is crowded with eager young people, and visitors have good reason to gape. On our first visit to the University of Moscow, a large delegation of Chinese, half of them apparently in the uniform of army officers, was being shown about. It would be an understatement to say that they seemed to be impressed.

As for medical education, this is a subject in itself and one which might well require a special mission if an adequate report were to be made. Perhaps it is enough to say that there are about 75 medical schools in the Soviet Union, the largest ones being in Moscow and Leningrad. About 70 percent of the students are women, the classes are enormous according to our standards, and, interestingly enough, students are paid for going to medical school—and to postgraduate medical school, should they desire to continue their formal education after some 3 to 5 years of practice.

The early days of our 2-week stay in Moscow were spent in reviewing, with local authorities, the special interests and desires of the mission. These were to determine certain lines of research in microbiology which were being pursued, to gather as much data as possible about the prevalence of infectious diseases in the Soviet Union, and to find out what methods were being employed for their prevention or control, what types of vaccines were employed, how they were produced, how effective they were, and on what basis their immunizing power depended. Time was also spent in discussing how the published works of Russian scientists might be brought more advantageously to the attention of American medical scientists. These things and this kind of talk properly belong to the world of science, which should not be limited by national or political boundaries. Our mission was not one of "espionage."

In outlining the program which was eventually followed, the Soviet Ministry of Health took the lead, leaving no doubt, after a full morning's briefing, that the rigid schedule we were to follow was to be in their hands at all times. In retrospect, however, it would seem that whatever was eliminated from our list was omitted more from the standpoint of "practicability" than for any other reason which one might imagine. The Ministry of Health is all-powerful in the Soviet Union when it comes to the control of medical matters, supervising, as it does, medical education, research institutes, and the public health service of all 16 republics. Under its aegis we were soon launched on a round of visits which eventually covered more than 25 research and educational institutions and brought us into contact with more than 200 scientists and physicians.

These institutes, which are organized either under the Ministry of Health or under the Academy of Medical Sciences, deal with a variety of scientific and practical activities, including vaccine and serum production. In Moscow, they include the Gamaleya, the Ivanovsky, and the Metchnikov institutes; in Leningrad, the Institute of Experimental Medicine; and in Kharkov, the Ukrainian Institute of Vaccine and Serums. All are dedicated to the carrying of Soviet medical science to a position of prominence in the world. As a result of these visits we were soon laden with hundreds of reprints, books, and pamphlets and also with samples of vaccines and other biological products, to be studied and tested in this country.

Pavlov's Influence

One of the things in which Soviet medical scientists take great pride is their heritage, from the days of czarist Russia, of a tradition of excellence and dignity in some special branches of medical science. Seldom was one allowed to forget the mark left by Pavlov, the great physiologist (who was not particularly sympathetic to the Communist regime). As the founder of a whole school of thought built around the conditioned reflex and its significance to the fields of internal medicine and psychiatry, Pavlov has now been elevated

M. B. Shimkin of the U.S. National Cancer Institute inspecting one of the classrooms and teaching laboratories for instruction in histology in one of the larger of the medical schools in Moscow. [Courtesy K. F. Meyer]

almost to sainthood in Russia. His reputation among neuropsychiatrists in that land certainly transcends that of Freud. In this field they also have Korsakoff, whose name is identified with a special kind of psychosis, and Bechterew, author of a great textbook on neurology. In pathology there is Anitschow, credited with first pointing out, some 40 years ago, that diet and "good living" might well be responsible for hardening of the arteries. This was proposed by him at a time when the idea was new and far from fashionable. In another field—immunology—a great figure, Metchnikov (who more properly belongs to France), is passionately claimed by the Russians as their own. In an age of science, these new heroes may soon compete locally with Peter and Catherine the Great.

Laboratories and Institutes

As for the laboratories, there was a distinct lack of chromium plate. Buildings usually seemed to be in need of repair, and the rooms were crowded. Here and there the apparatus was antiquated, and some of the usual supplies, such as glassware and reagents, were limited, by American standards; in other words, most laboratories were modestly equipped. But this was by no means true of all of them; in some laboratories large and expensive pieces of apparatus, such as electron microscopes of modern design, ultracentrifuges, Geiger counters, and oscilloscopes, were prominently displayed, and it was clear that a distinct effort was being made to show us that their equipment, if not up to American standards, was on the way up. Many of these items were of recent Soviet manufacture and of recent style; others were imported from East Germany and Western European countries. If the Russians were short on supplies and some pieces of equipment, they were, however, long on technical personnel in the form of trained man-, or more properly woman-, power. The sight of room after room, each with its quota of middle-aged women, who were apparently "in their jobs for life," working as technicians or as laboratory helpers, sterilizing glassware, cleaning the laboratory, and making themselves generally useful, was a sharp reminder of our own difficulties in maintaining an adequate supply of such people in the United States today. But one should be reminded that in the Soviet Union nearly everyone works at a government assignment. How much better it is for an able woman to be employed in a laboratory, even if it is at a menial task, than to spend the day cleaning the streets or carrying bricks in a hod.

Mention might be made here of the position of women in Soviet medical science. In the junior positions women were very much in evidence. This was less true of the top positions, although perhaps 15 to 20 percent of these were also occupied by women. Some of these women appeared to us to be unusually capable, endowed as they were with that rare combination of scientific judgment and the administrative capacity to deal with a large staff, which no doubt had its quota of difficult personalities. Administration with them was not spelled with a capital *A*. The paraphernalia of office facilities, which have become an integral part of laboratories of this type in the United States, were conspicuous by their absence. The typical Soviet office secretary or clerk seems

Colin M. MacLeod, member of the U.S. medical mission to the U.S.S.R., examines specimens which are being explained by a professor of pathology at the Institute of Experimental Medicine in Leningrad.

to be an elderly woman who records entries with pen and ink in a thick, bound ledger. No calculating machines, and few evidences that modern statistical methods were being used, were apparent.

It was, however, our joint belief that the senior staff members and top figures of Soviet medical science certainly included men of scientific stature. We met many talented and original scientists who were well acquainted with modern techniques and well supported in their facilities for work, and who had considerable freedom from the kind of administrational distractions which plague so many research workers in our own country today.

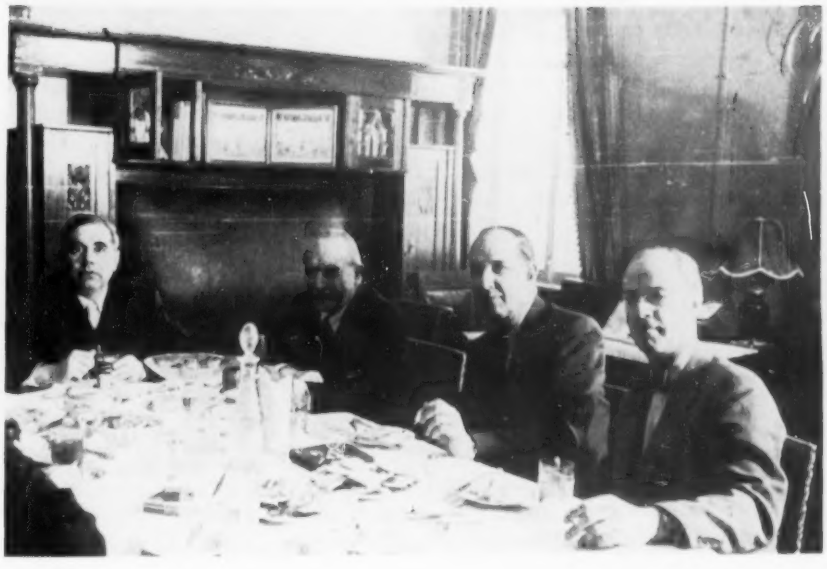
Of the calibre of work in the field of microbiology in the Soviet Union, it may be trite to say that it impressed us as being good, bad, and indifferent, just as might have been the case in many other places. The fact that the theories on which some of the work was based were novel and that the techniques were unfamiliar did not indicate to us that such work was unsound. It is not surprising that new *fashions*, foreign to American scientists, should have developed in an isolated country whose recent scientific literature has not been generally available or has, at least, seldom been translated into English. Some of our failure in attempting to follow what has been going on in the U.S.S.R. stems from the widespread belief that the whole structure of Soviet biological science is flimsy; this impression was strengthened as a result of the stories about men such as Lysenko in the field of genetics. In Lysenko's case, a government decree backed up a personal and, to say the least, a controversial opinion. This episode, which suggested a dictator's arbitrary decree about scientific thought, occurred some years ago. Today, in Soviet scientific circles, Lysenko is not a happy subject of conversation. To our surprise, differences of opinion were openly expressed about the soundness of this or that scientific view. Soviet science today does not seem to be quite as cramped and cribbed as had been thought to be the case.

Soviet Fields of Research

The subjects to which the scientists are now turning special attention are certainly timely. Leading the list is the field of neurophysiology, cerebral functions, and studies of the pattern of events which shape human behavior. Also high on the list of priorities is the field of cancer research. This commands great attention. Several institutes are wholly devoted to research on malignant tumors which concerns investigations regarding the causes of cancer, the possibility that a virus plays some part, and a variety of methods of therapy, ranging from x-rays to the use of plant extracts.

Also high on the list is the whole field of preventive medicine, with programs primarily directed against infectious disease such as influenza, whooping cough, undulant fever, tularemia, and Russian forms of encephalitis. Their serum and vaccine institutes have been far from idle during the past decade. Some of them had thrown in their lot with so-called "live" vaccines (as opposed to the inactivated or killed variety) for use in man on a far wider basis than is the case here. As an example, there are extensive annual vaccination programs for the control of influenza.

Apparently, influenza and influenza epidemics occur with greater frequency and greater regularity each winter in the Soviet Union than in the United States or even in most parts of Europe. Outbreaks are attributable to the familiar types A, B, and C



Luncheon at the All Union Institute of Veterinary Ectoparasitology, Mycology, and Sanitation, Moscow. (Left to right) A. A. Pallicov, director; K. F. Meyer, of San Francisco; R. E. Shope and Colin M. MacLeod, of New York. Much scientific discussion takes place over the luncheon table in the U.S.S.R.

of influenza virus which are common throughout the world today, and apparently they recur each year, causing a vast amount of acute illness and time lost from school or work. As is usual in Russia, we encountered difficulty when it came to finding out just how prevalent influenza (or many another disease) had been; what was the attack rate; which types (A, B, or C) had been the most prevalent; and whether children or young adults or old people were the hardest hit, or whether all ages were involved. Without adequate figures, our estimates of the situation could only be limited. Nevertheless, it did seem clear that, for the last 6 or 8 years, Moscow had been swept each winter by one or more large "epidemics of flu."

To meet the influenza situation in the Soviet Union, Zhdanov, the Deputy Minister of Health, informed us that between 10 and 12 million people in Russia had recently been vaccinated against influenza with *live virus* vaccine and that the present plan was to include all school children in the big cities, and certain industrial workers, in an annual program of vaccination, which takes place in the autumn of each year. Since the vaccine is administered with a nasal spray, the logistics of carrying out this program are simpler than if the vaccine were administered with a hypodermic syringe (as is done with most influenza vaccines the world over). The Soviets claim that the influenza rate in adults has been reduced by some 66 percent as a result of vaccination, but that further work on its evaluation is still in order and will be pursued.

The question of the relative virtues of inducing immunity with a killed or a live (attenuated) vaccine, whether it be for influenza or for poliomyelitis, is a problem for immunologists, over which they will probably continue to wrangle for some time. Among the virtues of the live vaccine is the fact that it actually produces a mild infection from which immunity should be at least as lasting and as potent as that derived from a *natural* infection. Among the liabilities of the live vaccine is the possibility that its capacity to infect might get out of hand and that the agent might spread from the vaccinated person to others; thus, lurking in the background, is the thought that the "tame" infective agent, although domesticated in the laboratory, might revert to its former "wild" state.

The decision to throw in their lot with live vaccine programs in man in preference to vaccines killed by chemical or physical agents is one which has apparently been adopted by Soviet medical scientists and incorporated into their present plans after considerable experience and many field trials. Although their experience with poliomyelitis is limited, Chumakov, director of the Poliomyelitis Institute in Moscow, has been recently quoted as saying that their attack on this disease may include work with live virus vaccines.

One can see, therefore, with what interest physicians in this country will follow these trials or programs of live virus immunization against influenza and other human diseases that are now being carried out on a large scale in the Soviet Union. This is only one of the Soviet medical programs from which we have something to learn.

A final note on which this account will end is

the apparent earnestness of Soviet science, as manifested by its devotees, among whom there are many dedicated men and women. These people may not be entirely sure of themselves but they are anxious to respond to the challenge that faces them. An analogy could even be drawn here between their scientific and athletic ambitions. We had the opportunity to discuss this with a British newspaper correspondent, whose assignment in the U.S.S.R. was to find out why and how the teams from the Soviet Union had been so successful, of late, in the Olympic games. This had brought him to a consideration of three factors—unlimited manpower, intensive training courses, and a zealous determination to excel, not only on the part of the individual but in conformity with the desires of the state. These same features, we decided, might well apply to those fields of technical science which we had come to investigate. The Soviets' system may be vulnerable to criticism, today, from the standpoint of its rigidity, its overemphasis on practical applications as the one and only object worthy of support, with less opportunity for work in basic science, and its system of limiting personal initiative and rigidly controlling the planning of experiments. It is doubtful, however, that this trend will last long. If one might be brash enough to make a prediction, mine would be that, within the next 10 or 15 years, numerous very important results and ideas in the field of applied microbiology will come from the Soviet institutes which we visited, and that of these the scientific world will have to take more notice than has heretofore been the case.

References and Notes

1. Members of the U.S. mission were Colin M. MacLeod (then of New York University College of Medicine, New York), Karl F. Meyer (University of California Medical School, San Francisco), John R. Paul (Yale University School of Medicine, New Haven, Conn.), Richard E. Shope (Rockefeller Institute for Medical Research, New York), and Michael B. Shimkin (National Institutes of Health, Bethesda, Md.). A brief technical account of this U.S. mission appeared in *J. Am. Med. Assoc* **162**, 656 (1956).
2. Members of the Soviet mission were M. P. Chumakov, director, Poliomyelitis Research Institute, Academy of Medical Sciences of the U.S.S.R.; M. K. Voroshilova, senior research worker, Poliomyelitis Research Institute, Academy of Medical Sciences; A. A. Smorodintsev, director, department of virology, Institute of Experimental Medicine, Academy of Medical Sciences; and Lev Ivanovich Lukin, junior scientific employee.
3. The Problem Plan for Scientific Research by the Academy of Medical Sciences U.S.S.R., 1956–60. An abridgment and critique of this plan has recently been published [*Yale J. Biol. and Med.* **29**, 377 (1957)].

BOOK REVIEWS

Physics for Everybody. Germaine and Arthur Beiser. Dutton, New York, 1956. 191 pp. Illus. $3.50.

In this slim book, Germaine and Arthur Beiser have undertaken an ambitious task. They have written an introduction to physics for the intelligent layman. Recognizing that their intended reader has a limited mathematical background and little inclination to wade through a conventional textbook in physics, the authors have attempted to provide him with a very readable book without distorting the nature of the field.

There are many ways of tackling such a difficult problem. The Beisers have chosen to follow the approach of an orthodox introductory textbook. Their version is scaled down, written in a pleasant, informal style, and decorated with amusing drawings at the head of each chapter, but it is a small-scale textbook, nevertheless. It contains the usual order of subject matter—mechanics, sound, heat, electricity and magnetism, optics, and modern physics—and, regrettably, touches on almost as many of the phenomena in those fields as would a textbook used in a full year's course.

This is done in such a short volume at the cost of detail. As the authors point out, too much attention to detail can obscure the delightful simplicity of many physical principles. Too little attention to detail, however, prevents the reader from ever grasping the meaning of these principles, especially when new definitions, new concepts, and new principles are introduced in bewildering profusion in a few pages. In a rather extreme example of this, reflection, refraction, dispersion, interference, diffraction, polarization, and scattering are discussed in the space of three pages.

Not only does the book cover too many subjects too quickly, but it neglects the quantitative nature of physics. Lip service is paid to this, but few specific problems are solved, and few of the many formulas are applied. The reader consequently gets some feeling for the wide range of physics, but it is doubtful that he learns very much of the subject matter covered. I feel that a truer picture of physics would be given in so short a book by choosing a few typical problems and studying them carefully, in detail.

Within the limitations of their approach (it is a measure of the difficulty of the task they set themselves that any approach would have many limitations), the Beisers have been reasonably successful. Their book contains a few small mistakes and some awkward sections, but is essentially an accurate survey of physics. It is clearly written and frequently manages to make even very sophisticated physical ideas understandable. These qualities are particularly prominent in the sections on modern physics.

Credit should be given to Richard Witkover for his excellent diagrams and to Sol Ehrlich for his delightful drawings. They are a great help to the authors in achieving as much as they do in this ambitious little volume.

HOWARD LASTER

University of Maryland

Introducing Astronomy. J. B. Sidgwick. Macmillan, New York, 1957. 259 pp. Illus. + plates. $3.50.

It is said that Arthur Eddington used to set aside his theoretical researches and sneak up into the dome for a look at the moon or the rings of Saturn, if he thought nobody was around. If so, it illustrates J. B. Sidgwick's point that "the man who confines his astronomy to the armchair is as far from the real thing, the genuine *frisson* that results from direct contact, as one whose experience of music is confined to the reading of press notices of concerts." There is widespread interest in outer space these days, and there are many popular books available. It is all very nice to know the simple facts about stars and planets, but to have firsthand acquaintance with them in one's own yard is the proper way to realize the joys of astronomy. This attractive little book "aims at introducing the reader to the wonder and fascination of the night sky" and can very well be recommended to those who are about to do some observing of their own.

The first two chapters summarize the notable contributions of amateurs in various branches of the science and give practical suggestions on the uses of binoculars and small telescopes and even on how to keep warm and when to take hot drinks (after the outing). The diurnal and annual rotations of the sky and the motions of the moon and planets are carefully explained. These are the matters that confuse and discourage the novice.

The second part (a third of the volume) is devoted to a summary of astronomy. Here it becomes evident that the publishers have taken an old book (1951), directed toward British readers, and intro-

duced it to Americans in 1957 with no changes whatsoever. It may be unimportant that another moon has been added to the known retinue of Jupiter or that the solar distance is nearly a round 93 million miles rather than 92,870,000 (a figure that was obsolete even in 1951). But there is no excuse for overlooking the revolution that is now going on with the aid of radio techniques and simply leaving it that "beyond establishing that the intensity of 'cosmic static' varies with the amount of galactic material in any given direction, nothing yet is definitely known of its source or mode of generation." The treatment of cosmic rays is correspondingly poor. Even for British readers, the omission of any mention of *Sky and Telescope* as a periodical of interest to amateur astronomers is inexcusable.

The latter half of the book consists of an excellent set of star maps, of which the first four show the complete northern sky at four seasons of the year. Then follow about 50 charts of individual constellations with descriptive notes on mythology and on objects of special interest. On each map is shown a scale of angular size—a line showing approximate handbreadth with the arm fully extended, about 13 degrees.

WILLIAM A. CALDER

Agnes Scott College

Medicine in a Changing Society. Lectures to the laity, No. XVIII. Iago Galdston, Ed. International Universities Press, New York, for the New York Academy of Medicine, 1956. 166 pp. $3.

Medicine in a Changing Society is a collection of "lectures to the laity," sponsored by the New York Academy of Medicine. Like so many other collections of essays, this one lacks unity of style and viewpoint. Its title may mislead the unwary reader, for there are many aspects of both "medicine" and "changing society" which are not dealt with. The high level of abstraction which characterizes most of the essays will perhaps frustrate the reader who seeks specific information.

Despite these criticisms, I read the volumes with interest, pleasure, and—I hope—profit. In the opening essay, "Adventure and security in a changing world," Franz Alexander speaks feelingly of two fundamental and conflicting drives which affect human behavior—a search for stability on the one hand and for adventure and creativity on the other. John Rose, in the second essay, "Changes in family life and mental health," describes the plight of today's parents, so many of whom have lost faith in their ability to fulfill the parental role, and points up the fact that communication between professional child-care experts and parents is often poor, with resultant mutual misunderstanding and lack of trust.

William Malamud, in his essay, treats certain fundamental relationships between "Organic factors and personality functions." In the least abstract of the various essays, "What the laboratory can teach us about nervous breakdown," W. Horsley Gantt relates some basic findings of studies in the experimental psychology laboratory. He concludes with a plea for "further development of the conditional reflex method for detecting susceptibility to nervous breakdown [which] might lead to a rational *basis for a preventive psychiatry*. . . ."

The concluding essay, by the editor of the volume, Iago Galdston, is entitled "Salerno and the atom." It is a delightful, erudite dissertation on the history of the philosophy of medicine through the ages, the changes this philosophy has undergone, and some of the results of these changes. In conclusion, Galdston describes "Comprehensive medicine" as an ideal type of medical practice which, combining the best features of ancient medicine and scientific medicine, will best serve the "philosophy for health."

The purpose of an index in this volume is not at all clear, for this is in no sense a reference work.

ROBERT B. HOWARD

University of Minnesota

The Classification of Lower Organisms. Herbert F. Copeland. Pacific Books, Palo Alto, Calif., 1956. 302 pp. Illus. $7.50.

Herbert Copeland has spent much of his life brooding over systematic arrangements, and it is not surprising that by now he is obsessed with the subject. He is further afflicted with the prevalent disease in systematics of raising the ranks of groups and must have inhaled vast quantities of ancient dust in resurrecting group names out of the past. In *The Classification of Lower Organisms* he seems to have followed the principle of selecting the oldest name, although this is not definitely stated. This principle is fair enough in theory, but in practice I have found that zoologists resent any alterations of familiar group names. One must agree with the author's viewpoint that systematic arrangements are unstable because of imperfect knowledge and that rearrangements are inevitable with increasing knowledge. But there is no knowledge that supports some of the attitudes—for instance, that Protozoa are not animals, at least in large part.

As he has done before, Copeland acknowledges four kingdoms, under the names of Mychota (formerly Monera), Protoctista (formerly Protista), Plantae (usually Metaphyta), and Animalia (usually Metazoa). I am unsympathetic with the category "kingdom" and consider it arbitrary and unnecessary. For instance, fully developed plants and animals are obviously widely distinct, but at the lower levels they are indistinguishable. Arbitrary distribution of these intermediate forms in different categories does not assist in the understanding of them and may falsify the facts. For instance, it is known that the colorless flagellates of the genus *Astasia* are merely strains of *Euglena* that have lost their chlorophyll. Probably no zoologist will accept the definition of animal as an organism that has blastula and gastrula stages. This definition appears to have been invented by Copeland to dovetail with his categories.

Apart from two introductory chapters, the book is confined to the details of classification of the two "kingdoms" Mychota and Protoctista. The former includes the bacteria and blue-green algae and is defined as organisms that lack nuclei. The meaning seems to be a lack of formed nuclei, since chemical substances characteristic of nuclei are admitted to be present. Formed nuclei are recognized as being "essentially a device for sexual reproduction"; yet it is now known that bacteria, which are said not to have nuclei, exhibit sexual phenomena.

The kingdom Protoctista, made up of a conglomeration of red algae, brown algae, fungi, and Protozoa, is repugnant to me. There is no doubt justification for distributing some flagellates among the algae, although in fact it has never been decided whether flagellates are algae or protozoans, and they are claimed by both botanists and zoologists. It is probably impossible ever to arrive at a decision on this matter because of the numerous transitional forms and cases like the Astasia-Euglena situation that I have mentioned.

Recent years have seen the elevation of the old familiar classes of Protozoa to the rank of subphylum, but no protozoologist has as yet divided up the Protozoa into phyla. Copeland distributes the Protozoa among five phyla, one of which (Phaeophyta) also contains the brown algae. The pigmented flagellates are placed in a phylum Pyrrhophyta; the colorless ones are united with what are ordinarily called rhizopods in a phylum Protoplasta; the Sporozoa parade under the strange name of Fungilli, resurrected out of Haeckel, who is Copeland's guiding spirit; and a final phylum, Ciliophora, includes the ciliates. The union of flagellates with rhizopods had already appeared in the *Traité de Zoologie* as a subphylum Rhizoflagellata, but all flagellates were included. It is certainly impossible to delimit flagellates from rhizopods, but uniting them has not proved helpful. The gap between ciliates and other Protozoa is generally acknowledged, but Sporozoa have affinities with flagellates and rhizopods. In subordinate groups of Protozoa there is the expected raising of rank and alteration of familiar into unfamiliar names.

The immense labor obviously spent on this book may be rewarded by the eventual adoption of some of Copeland's suggestions. There is an extensive bibliography.

L. H. Hyman

American Museum of Natural History, New York

Sedimentary Rocks. F. J. Pettijohn, Harper, New York, rev. ed. 2, 1957. 718 pp. Illus. + plates. $12.

Sedimentary Rocks, by F. J. Pettijohn, is a basic book of general interest to every geologist. The volume, as its title states, describes the fundamental properties of sedimentary rocks—one of the three major rock types the geologist encounters in his work. This second edition has been completely rewritten and expanded; only the original structure and outline remain the same. Many of the figures, plates, tables, and references are new. The book contains 173 figures, 40 plates, 119 tables, and more than 1600 references, by 750 authors. The references are tabulated according to 54 topics, instead of being in footnotes, as in the first edition.

Pettijohn's general approach to the subject is a discussion of (i) texture, composition, and structure; (ii) classification; (iii) different types of sedimentary rocks; (iv) source, transport, and deposition of sediments, including a description of weathering; (v) lithification and diagenesis; and (vi) historical geology of sediments. The last topic is new in the second edition.

Pettijohn's descriptions of graywacke and limestone are outstanding. The section on transport does not cover the intensive work on sediment transport that has been undertaken in recent years by hydraulic engineers, such as H. A. Einstein, J. W. Johnson, and others. The section on classification might have included a description of the classifications used by engineers. The book might also have contained a short account of common words, such as *consolidation, compaction, soil,* and *clay,* that are used in different ways by geologists and engineers. In the first edition the author used a number of terms that had not previously been in general use in describing particular types of sedimentary rocks.

He continues to use these terms in the second edition. During the 9 years since the first edition appeared, geologists have come to find that many of these terms are useful, because they relate to types of sedimentary rocks that had not been clearly differentiated before. Pettijohn may have helped geologists greatly by his analytic approach to the problem of differentiating sedimentary rock types and by the introduction of these new terms.

It has been a real pleasure and education to read this second edition of *Sedimentary Rocks*. The work of the author is highly commendable throughout. The book is well edited and contains good indexes of authors and topics.

PARKER D. TRASK

University of California, Berkeley

Christian Theology and Natural Science. Some questions on their relations. E. L. Mascall. Ronald Press, New York, 1957. 328 pp. $4.50.

Is it possible for one who understands and accepts modern natural science also to maintain an honest and wholehearted orthodox Christian faith? The author of this excellent book thinks the two are quite compatible—indeed, at many points, positively congenial—and he argues this by an able and fairly detailed analysis of several fundamental questions which have elements common to both theology and science.

Mascall's work is important for at least three reasons. First, the author is adequately informed, for his task, in the fields of science, philosophy, and Christian theology. He limits his discussion to topics in which he has detailed knowledge, of professional quality. Second, he largely avoids the romanticism of so many attempts to relate religion and science. He does not try to build a new religion from the findings of the scientists, nor does he comb the sciences for scraps of evidence to shore up his traditional Christian beliefs. Instead, he is consistently critical, cautious, realistic, even hard-headed, in his appraisals of the theological bearings of modern science. Third, in place of making an eclectic compromise, which would do justice neither to science nor to his faith, he restricts himself to an exploration of the boundary between well-defined religious and scientific concerns, thus posing the questions of interrelationship in sharpest relief.

The conclusion which consistently emerges from this inquiry is that there is nothing in natural science which either coercively proves or disproves such traditional Christian doctrines as Creation, Incarnation, Original Sin, freedom, and redemptive purpose. In general, it appears that recent findings in science and in the philosophy of science make obsolete the older materialistic and deterministic dogmas as literal and complete descriptions of reality and thus make room for the Christian view of a world sustained in existence by the transcendent God, who became incarnate in Jesus Christ.

Mascall does not argue the case for Christianity in this book. He has done that, as an Anglican Thomist, in earlier works. One who was not already a convinced, orthodox Christian could hardly be converted to the faith through reading the present volume. A thoroughgoing modernist (like myself) or a secularist would probably wonder how an able and scientifically-trained scholar could so confidently accept the outlook of traditional Christian theism. He would also doubtless reject the sharp distinction made between scientific beliefs and metaphysical or theological beliefs, which alone permits the author to be both scientific and orthodox Christian. But every reader ought to be grateful to Mascall for showing persuasively that modern scientific investigations neither exclude nor directly settle the ultimate questions of human nature and destiny but provide occasions for facing them with fresh insight and renewed devotion.

PHILIP H. PHENIX

Teachers College, Columbia University

Disaster. A psychological essay. Martha Wolfenstein. Free Press, Glencoe, Ill. and Falcon's Wing Press, Indian Hills, Colo., 1957. xvi + 231 pp. $4.

In *Disaster*, Martha Wolfenstein is concerned with subsuming a great variety of data on human reactions to disaster under some psychological principles and concepts which have been serviceable in understanding many other human situations. The result is an interesting, informed, and imaginative treatment.

In keeping with her major professional orientation, the concepts which she invokes are preponderantly those of contemporary psychoanalysis. They reflect an emphasis on the consequences of repressed and unconscious wishes and conflicts. They derive considerable plausibility, in application to disaster-behavior, from the evident fact that threat and stress and mass suffering are as likely as anything in this world to arouse, in human beings, latent problems of infantile guilt, anxiety, and dependency which few of us ever quite successfully resolve. Thus, for example, "A feeling of being abandoned probably plays a major part in the emotional distress of a disastrous experience. This feeling has its roots in early childhood. The small child

becomes anxious when mother is away because he is helpless to satisfy his own needs and is in danger of being overwhelmed by distressing feelings which he cannot himself alleviate. Later danger situations are apt to reactivate the feelings related to earlier ones. . . . Being alone in such a situation is likely to be particularly devastating" (page 57).

Similarly, Martha Wolfenstein's conceptualizations are sensitive to that dependence of behavior on particular cultures which the best of psychoanalytic thinking nowadays seldom forgets. Some of her most provocative interpretations point to what people are extremely likely to do in disasters in America—that is, in a culture in which such matters as manliness, self-reliance, optimism, emotional control, and happiness are tenacious values around which has been woven a network of taboos and expectations concerning behavior.

The data on which the author's thinking bears were not, as she explains at the outset, gathered by her. Rather, she has worked ingeniously and productively with interview protocols already gathered in primary research done for the National Research Council Committee on Disaster Study; she has used, most of all, the rich material in studies by Clyde Hart's National Opinion Research Center and Harry Moore's study of the Waco-San Angelo tornados, done at the University of Texas. It is a mark of her scientific caution that she does not claim to have proved any of her many hypotheses by the excellent illustrations of behavior which she furnishes. The book is, as she says, an adventure in hypothesis-building; the job of testing will be with disaster-researchers for a very long time.

DWIGHT W. CHAPMAN

Vassar College

Milton and Science. Kester Svendsen. Harvard University Press, Cambridge, Mass., 1956. 304 pp. Illus. $5.50.

During the 19th century, Milton criticism, mindful of the Renaissance ideal that the poet should be the teacher of his age and "a curious universal scholar," tended to magnify not merely the *breadth* but likewise the *depth* of Milton's learning and to extol him as profoundly expert in the specialized scientific knowledge of his times. The essential inconsistency of this distorted view has become clearer as our knowledge of 17th-century science has been increased through modern historical research.

As a great literary artist, making skillful use of science for his own poetic purposes, it would have been a mistake for Milton to expound a science so advanced as to be understandable only to the most expert scientists among his contemporary readers. Milton the artist was rightly concerned only with ideas familiar to all of his educated contemporaries. His "fit audience though few" was not one intentionally restricted to a select group analogous to the six mathematicians reputed some 35 years ago to be the only persons capable of understanding Einstein's theory of relativity. In short, Milton spoke to an audience composed of the average well-educated men of his day and was rightly content to leave the more involved intricacies of scientific subjects to properly qualified experts. This is the balanced and sensible view concerning Milton and science that is set forth throughout Kester Svendsen's useful book.

Svendsen's method, as in various articles published in scholarly journals over the past 10 years, is to demonstrate that Milton's employment of scientific ideas and materials in his literary masterpieces is based on the common knowledge to be found expounded in the various encyclopedias widely known and universally consulted by men of the 17th century. The eight major chapters of the book are devoted to the presentation of evidence of the correspondence of Milton's ideas on the physical world of nature with those expressed in the current encyclopedias. By thus citing at length from chapter and verse, Svendsen amply proves his point that Milton was not ahead of his time in detailed scientific knowledge but, in fact, lagged behind it to the extent that the general level of well-informed knowledge as recorded in popular encyclopedias fell short of the latest ideas accepted by the specialists in the forefront of the various active fields of scientific investigation.

Therefore, although the effect of Svendsen's book is to lower Milton's rating as a scientific specialist of the 17th century (a matter of no real significance), it in no wise derogates from Milton's standing as a literary artist. By speaking in terms that he knew his audience would understand and accept, Milton wisely avoided confusing them, to the detriment of his art, by expounding notions to which they were not yet ready to accord their unquestioning assent. Consequently, in Book X of *Paradise Lost*, he was content to contrast the new heliocentric cosmology of Copernicus with the old, unmodified geocentric cosmology of Ptolemy, hallowed by poetic use from the times of ancient Greece and continuing through the Middle Ages, rather than to introduce the compromise geo-heliocentric system of Tycho Brahe, which, at the middle of the 17th century, was the only system that had any standing among scientists to support a claim to rival that of Copernicus.

In short, Svendsen's book is the best comprehensive scholarly treatment of Milton and science at present available and will thus prove of great benefit to any Milton student.

FRANCIS R. JOHNSON

Stanford University

America's Natural Resources. Charles H. Callison, Ed. Ronald Press, New York, for the Natural Resources Council of America, 1957. 211 pp. $3.75.

No more realistic picture than this of our interrelated resources has been previously available to the public. During the course of this century, the spotlight has shifted from forests to game, to soil, to water, to wilderness, with special groups arising to defend each in turn. Now the Natural Resources Council of America, representing 40 conservation organizations, has sponsored a book that puts America's natural resources in unified perspective. It is addressed to all thoughtful citizens. Written for the layman rather than the expert, it is equally worth the expert's study for the comprehensive picture it provides.

Charles H. Callison, chairman of the editorial committee (which includes Henry Clepper, Michael Hudoba, and Richard Westwood) states in the preface that the goal "has been to advance the attainment of sound management of natural resources in the public interest." The keynote of interdependency is given by Shirley W. Allen in the first chapter, "Conservation: an ecological approach." Next, Fairfield Osborn reveals the sharply accelerating pressures of the world's peoples and wants in "Renewable resources and human populations." Each major type of resource (with the exception of minerals) is discussed by an expert: Firman E. Bear, "Soil"; H. G. Wilm, "Water"; David F. Costello, "Grasslands"; Henry Clepper and Lowell Besley, "Forests"; Joseph J. Shomon, "Wildlife"; Albert S. Hazzard and William Voigt, Jr., "Fish"; and Howard Zahniser, "Parks and wildernesses." Edward H. Graham, in "Land use principles and needs," shows how the land, its values, and its people must be understood as an indivisible whole. The problems and tactics for achieving this goal are discussed by Ira N. Gabrielson in "Needed: a natural resources policy." An appendix contains the text of "A policy for renewable natural resources," which the Natural Resources Council recommends for Congressional action.

The presentation is simple but authoritative. Although the writing is carefully objective, the authors' deep concern and dedication to high purpose cannot be concealed. Each contributor discusses his topic in whole perspective. For each specific resource there is an explanation of its essential values and characteristics. Our past practices are reviewed, and the present status of knowledge and management is reported. Then come directions for further improvement, with mention of the agencies that are concerned in the work. There is very little of the statistical or the ephemeral. Perhaps those readers who are least familiar with their environment may skip the paragraphs here and there which discuss, in detail, plants and animals that they have never seen. It is not easy to portray a resource without mention of its parts; pictures might have helped. Good references are supplied for further background.

This book is based on assumptions which most Americans profess: that government exists to serve the interests of all the people; that it is the people themselves who are the source of policy; that the people will judge wisely if sound information is available. No separate chapter on the ethics that underlie conservation is provided. Implied is the faith that when people sufficiently understand our resources they will choose to act in the public interest. Probably it is too much to ask that the same book should attempt to convert those people who would choose otherwise. It cannot be denied that such people do exist—among the ablest entrepreneurs, among the most industrious farmers, even among the keenest sportsmen and wildflower pickers. The command to respect one's neighbor as oneself is by no means universally honored, even after nearly 2000 years of preaching. Its practice is even harder now that one's neighborhood includes all the living earth. At any rate, the present authors rely on the tactic of informing rather than reforming. They present to all people of conscience a fundamental area for attention that too many have heretofore overlooked.

Nevertheless, evocative ethical reminders do appear, flashing forth, frequently, as a sentence or paragraph among the practical expositions: "Equitable distribution . . . among the present inhabitants of the earth and those who are to come"; "What, after all, is an *optimum* population for this nation of ours?" (italics mine); "Now we know 'that there is a point where independence becomes irresponsibility and liberty becomes license' "; "All our laws . . . are of little avail . . . unless they become a part of the knowledge and conviction of those who manage the land."

Another gratifying feature of the book is the esthetic sensitivity which is evident on many pages: "The emphasis [on wildlife] will have to be away from *kill* and *meat* to *let live, share,* and *enjoy*";

"We work for wilderness preservation not primarily for the right of a minority . . . but . . . to preserve for all the freedom of choosing to know the primeval if they so wish"; "In its potentialities for fulfilling an appreciation of the aesthetic, we find the most delicate and sensitive value that can be ascribed to land."

It is well that the scientific considerations of resource management have here been illuminated by reference to the ethical and the esthetic. As in mapping by triangulation, it is necessary, in fixing an objective, to establish bearings from different directions. In our devotion to scientific reason we sometimes forget that goodness and beauty are also valid observation points.

The book reaches a focus in the discussion of land-use principles and in the statement of the "Policy for renewable natural resources," at the end. It is to the credit not only of the writers and editors but of the nation's conservation organizations which they represent that a unified conservation philosophy emerges here so clearly. This marks the approach of maturity in resource management. The results of this advance have already been evidenced on the national scene, where, with increasing frequency, the proponents of single-purpose or exploitive use have been overruled for broader considerations. The new vision that is apparent in this excellent book should be widely presented to the public. Unfortunately, the book's cover and format are unimpressive for this day of "eye appeal." It is to be hoped that its readers will make up for this shortcoming by their own testimony.

KENNETH W. HUNT

Antioch College

Seitaro Tsuboi Commemorative Volume. By his pupils and colleagues. Geological Institute, Tokyo University, Tokyo, Japan, 1955. 495 pp. Illus. + plates.

This volume consists of a collection of papers on mineralogy, petrology, and geology, dedicated to Seitaro Tsuboi of the University of Tokyo by his pupils and colleagues on the occasion of his 60th birthday. It begins with a brief foreword that expresses the appreciation, admiration, and affection of his pupils and colleagues and highlights a few of the many reasons for their gratitude. The foreword is followed by a three-and-a-half-page review of Tsuboi's fruitful academic and scientific career, to date.

The remainder of the book is a collection of 34 papers by 48 authors. All of these papers have been published elsewhere. [The first 13 appeared as part II of the *Journal of the Faculty of Science* (University of Tokyo, 1954), section II, vol. IX, pages 193–354. The remaining 21 papers were published in other journals.]

It is not possible to cover the individual papers published in this volume in a brief review. However, the scope of the compilation may be indicated by the following breakdown: Petrology, 13 papers; mineralogy, 12; paleontology, 2; stratigraphy, 1; structural geology, 4; precision of measurement, 2. The petrologic papers include areal geology; studies of intrusive, extrusive, and metamorphic rocks; geologic thermometry; metasomatism and other alteration; and chemical weathering. The mineralogic papers include treatment of amphiboles, barium adularia, chloritoid, cinnabar, clay minerals, micas, pseudoleucite, pyroxene, quartz, symplesite, synthetic nepheline, and warwickite.

The main value of this volume to members of the geologic profession is that it brings together in one easily accessible volume a number of papers, some of which are important. It will prove useful to a large group of workers, especially since many of the papers are not readily available in Western libraries. The volume could have been improved by the addition of Tsuboi's complete bibliography, to date.

ROBERT L. SMITH

U.S. Geological Survey

Elements of Engineering Thermodynamics. Rolf H. Sabersky. McGraw-Hill, New York, 1957. 318 pp. Illus. $7.50.

The field of engineering thermodynamics inspires production of a continual supply of new textbooks. *Elements of Engineering Thermodynamics,* by Rolf H. Sabersky of California Institute of Technology, is typical of many which have appeared in recent years. Most of the textbooks which are currently being produced endeavor to present the subject in a compact and relatively simplified form, with one or more special engineering areas receiving primary attention. There appears to be a desire to avoid any strong emphasis on the scientific aspects of thermodynamics. The development of the text to meet a special situation generally means that many aspects of the subject are treated lightly.

This contribution is well organized and technically correct. It is a textbook that can be read easily and probably with understanding by the average engineering student. The author develops most of the fundamental concepts of thermodynamics, as contained in the first and second laws,

during his first ten chapters. These developments are handled in a conventional manner and at an elementary mathematical level. The exposition of the first and second laws is stated in terms of a conventional fluid medium of primary concern to mechanical engineers. Following the basic development, the author introduces the properties of perfect gases and—rather superficially, in two chapters—the properties of more general types of substances. The subject of imperfect gases is described essentially only in terms of the van der Waals gas. A simplified treatment of power cycles and their economic aspects is given in three chapters; these are followed by a discussion on selected jet propulsion systems. Five chapters are devoted to the thermodynamics of flow phenomena. A brief and almost superficial chapter on combustion concludes the text.

It is evident that this contribution is a development of a course given by the author, which, in his particular situation, is probably very satisfactory. As a general contribution, however, the text is so limited in content that any user would find it necessary to adopt the author's particular presentation without much deviation. Furthermore, the scientific fundamentals of the subject are presented so superficially that the text has little usefulness for purposes of reference.

There is so much of substantial value in the field of thermodynamics which can be applied to all aspects of engineering that it is unfortunate that textbooks are not written on the subject in a manner that indicates the broad scope and usefulness of this field. The conventional conception of thermodynamics by most engineers reflects the limited viewpoint of most authors. The needs of engineering today can be met most effectively by providing a broad base in such an area of engineering science as thermodynamics.

NEWMAN A. HALL

Yale University

Comfort for Survival. In nature and man. Angus M. Woodbury, Vantage, New York, 1957. vi + 104 pp. Illus. $3.

Angus Woodbury, a skilled naturalist-scientist in an old tradition, makes his own observations in the field, draws his own inferences, and thus semi-independently comes to about the same conclusions as other ecologists who rely more heavily on communication with their colleagues. Now he has taken some of his original observations from the southwestern United States and has blended them with liberal portions of the type of natural history often taught in elementary zoology courses to produce an unindexed little book that may prove to be readable and stimulating to the layman.

The professional ecologist may learn some interesting things about the animals of arid regions. He, however, will already be convinced that behavior patterns are subject to natural selection and that organisms may respond to environmental stimuli in adaptive ways that direct them toward optimum conditions for survival. When Woodbury calls this phenomenon "comfort-seeking" and says that the organisms find "satisfaction" and "serenity" in their responses, the scientist may question his right to disclaim the anthropomorphic implications with which these terms are loaded. It is easy to forget that comfort-seeking in the Woodburyian sense can be an unconscious response made by a plant.

I do not expect comfort-seeking to achieve recognition as a major driving force of evolution because adaptive behavior, like adaptive morphology, appears to be a consequence of evolutionary forces. Nevertheless, this small book is recommended for its sound observations on some little-known animals and for a number of stimulating speculations about genuinely difficult problems, such as that of the origin of butterfly emigration.

LAMONT C. COLE

Cornell University

A Textbook of Sound. A. B. Wood. Macmillan, New York, ed. 3, rev., 1955. 610 pp. Illus. $6.75.

This third edition of a standard reference work contains a considerable amount of new material over the second (1941) edition, notably on ultrasonics, hearing, noise, and the technical applications of sound. The book is divided into five parts that deal with (i) theory of vibrations, (ii) vibrating systems and sources of sound, (iii) transmission of sound, (iv) reception, transformation, and measurements of sound energy, and (v) technical applications.

The first part of the book gives an elementary description of some of the standard types of vibrating systems, such as tuning forks and tuned electric circuits, and introduces the subjects of plane and spherical waves in acoustic media. The second section deals, in a simple and descriptive manner, with vibrations of strings; transverse, longitudinal, and torsional vibrations of rods; vibrations of membranes, diaphragms, plates, and bells; vibrations in air cavities; and Helmholtz resonators. Such sound-generating methods as thermal methods, vortex sounds, and sirens are discussed.

All of the material in the first two sections was

contained in the first edition and can be described as traditional acoustics. The third section, on the transmission of sound, is the most valuable section of the book and clearly describes many of the more recent measurements and theories of the transmission of sound in absorbing and dispersive media. The parts on transmission of sound through the atmosphere and through the sea, which is the author's own field, are particularly useful.

The final two sections deal with fields that have developed considerably in the last 15 years—the period between the second and third editions—and do not, in my opinion, do justice to the great development that has taken place during this time. (Most of the instruments described date back to 1930 or before and are now largely obsolete.) The same comment is partly true for the section on applications. For example, one sees no mention of ultrasonic delay lines or ultrasonic drilling, cutting, and cleaning—subjects that loom large in present-day applications.

Nevertheless, as an introduction to the field of acoustics, the present volume has many advantages. It is easy to read and is well illustrated by figures. A barely essential amount of mathematics is included. The coverage is encyclopedic, and, as an introduction to the field of acoustics, *A Textbook of Sound* can be strongly recommended to engineers and acousticians.

WARREN P. MASON

Bell Telephone Laboratories

Human and Animal Ecology. vol. VIII of *Arid Zone Research*. UNESCO, Paris, 1957. 244 pp. $5.

As one who listened attentively to the Arid Lands Conference of 1955, held in New Mexico, I believe that a substantial case can be made for the view that the arid lands of the world now have taken about all they can take from man. Indeed, it seems likely that empirical methods, worked out in antiquity, represent a type of land use that science will be hard put to it to improve upon, if permanence is any consideration.

Nevertheless, we now have, as a conspicuous by-product of our present explosive growth in population, an increasing pressure upon these lands, comprising, as they do, some 35 percent of the earth's surface. Since this is true, science can do no less than appraise the situation, and UNESCO is a logical agency to request that service. Since the plant ecology of arid lands is relatively well known, a report on the ecology of man and other animals was requested. The papers, six in number, are in either French or English, with summaries in the other language.

The authors are Rochefort (who writes on human communities), Ladell (human biology), Bodenheimer (mammals), Etchecopar and Hüe (birds), Uvarov (locusts and grasshoppers), and Pradhan (other insects). The resulting abstracts and bibliographies will be of great value to students of ecology.

Rochefort discusses the traditional nomad and oasis cultures, showing how the former have, by virtue of their mobility, the economic upper hand and how serious the impact of modern technology on the old equilibrium may be.

Ladell develops the thesis that man, although a product of the tropics, seems not to have evolved any special physiological adaptation to deserts. Nevertheless, the range of his normal function is adequate for his adjustment, provided that certain cultural practices (which Ladell suggests) are observed.

Bodenheimer reviews the extensive, but still insufficient, literature on adaptive mammalian physiology. He points out the interesting fact that breeding seasons, although they differ widely among species, are such that the young are delivered at times of maximum green herbage.

The two authors who discuss the avifauna confine themselves to Arabia and the Sahara. Effects of the more obvious limiting factors are reviewed, sun, wind, and heat seeming to be less critical than dryness, which birds deal with by their great mobility and their practice of drinking when they can. A number of "laws" that have to do with adaptive coloration and body form are also discussed.

Uvarov's paper on locusts and grasshoppers is of particular interest, showing as it does how human interference with the biological equilibrium increases habitat suitable for the breeding of the migratory (and often pestilential) locusts. This is in line with American evidence that destructive Orthoptera and rodents tend to thrive on degraded plant communities.

Pradhan's analysis of his impressive bibliography leads him to conclude that our present knowledge is not sufficient to enable us to be forearmed against insect pests under intensified use of the arid lands by man.

All told, I find in this valuable document far more of warning than of promise.

PAUL B. SEARS

Yale University

Books Reviewed in SCIENCE

July 5

pH Measurements, Their Theory and Practice, V. Gold (Methuen; Wiley). Reviewed by R. G. Bates.

Allgemeine Meereskunde, G. Dietrich and K. Kalle (Borntraeger). Reviewed by W. S. Wooster.

Heterocyclic Compounds, vol. 6, *Six-Membered Heterocycles Containing Two Hetero Atoms and Their Benzo Derivatives,* R. C. Elderfield, Ed. (Wiley). Reviewed by R. L. Shriner.

Water for Industry, J. B. Graham and M. F. Burrill, Eds. (AAAS). Reviewed by R. L. Nace.

Advances in Virus Research, vol. IV, K. M. Smith and M. A. Lauffer, Eds. (Academic Press). Reviewed by F. B. Gordon.

July 12

The Presentation of Technical Information, R. O. Kapp (Macmillan). Reviewed by L. Svirsky.

Handbuch der Laplace-Transformation, vol. III, *Anwendungen der Laplace-Transformation,* G. Doetsch (Birkhäuser). Reviewed by T. J. Higgins.

Laboratory Engineering, vol. III, pt. II of *Technique of Organic Chemistry,* A. Weissberger, Ed. (Interscience). Reviewed by M. S. Peters.

The Leibniz-Clarke Correspondence, H. G. Alexander, Ed. (Philosophical Library). Reviewed by H. S. Thayer.

Hormones, Brain Function, and Behavior, H. Hoagland, Ed. (Academic Press). Reviewed by J. T. Velardo.

Models of Man, H. A. Simon (Wiley; Chapman & Hall). Reviewed by R. D. Luce.

July 19

The Enjoyment of Mathematics, H. Rademacher and O. Toeplitz (Princeton Univ. Press). Reviewed by E. Nagel.

Malaria, vol. 15 of *Bulletin of the World Health Organization* (WHO). Reviewed by C. G. Huff.

A Guide to the Literature of Chemistry, E. J. Crane, A. M. Patterson, E. B. Marr (Wiley; Chapman & Hall). Reviewed by C. M. Gottschalk.

An Introduction to Electrostatic Precipitation in Theory and Practice, H. E. Rose and A. J. Wood (Constable). Reviewed by E. P. Miller.

Precision Electrical Measurements, National Physical Laboratory (Philosophical Library). Reviewed by A. Norman.

The Horse-Flies (Diptera: Tabanidae) of the Ethiopian Region, vol. III, *Subfamilies Chrysopinae, Scepsidinae, and Pangoniinae and a revised classification,* H. Oldroyd (British Museum of Natural History). Reviewed by A. Stone.

July 26

The Life and Death of Cells, J. G. Hoffman (Hanover House). Reviewed by A. C. Giese.

Algebraic Geometry and Topology, R. H. Fox, D. C. Spencer, A. W. Tucker, Eds. (Princeton Univ. Press). Reviewed by S. S. Chern.

Chemical Applications of Spectroscopy, vol. IX of *Technique of Organic Chemistry,* W. West, Ed. (Interscience). Reviewed by D. E. Mann.

The Importance of Overweight, H. Bruch (Norton). Reviewed by J. Mayer.

Synthetic Polypeptides, C. H. Bamford, A. Elliott, W. E. Hanby (Academic Press). Reviewed by J. T. Edsall.

A Glossary of Mycology, W. H. Snell and E. A. Dick (Harvard Univ. Press). Reviewed by R. M. Page.

A Manual of Soil Fungi, J. C. Gilman (Iowa State College Press). Reviewed by J. N. Couch.

The Study of Plant Communities, H. J. Oosting (Freeman). Reviewed by F. R. Fosberg.

New Books

Fishes of the Red Sea and Southern Arabia, vol. I, *Branchiostomida to Polynemida.* Henry W. Fowler. Weizmann Science Press, Jerusalem, 1956. 240 pp.

Mammals of the Great Lakes Region. William H. Burt. University of Michigan Press, Ann Arbor, 1957. 246 pp. $4.75.

A Key to the Stars. R. van der Riet Woolsley. Philosophical Library, New York, ed. 3, 1957. 144 pp. $4.75.

Digital Computer Programming. D. D. McCracken. Wiley, New York; Chapman & Hall, London, 1957. 260 pp. $7.75.

Primates. Comparative anatomy and taxonomy. 3. *Pithecoidea.* Platyrrhini (Families Hapalidae and Callimiconidae). A monograph. W. C. Osman Hill. Interscience, New York; Edinburgh University Press, Edinburgh, 1957. 354 pp. $13.50.

Electricity and Magnetism. B. I. Bleaney and B. Bleaney. Clarendon Press, Oxford, 1957 (order from Oxford University Press, New York 11). 690 pp. $10.10.

Plant Classification. Lyman Benson. Heath, Boston, 1957. 702 pp. $9.

The Casting of Steel. W. C. Newell, Ed. Philosophical Library, New York, 1957. 607 pp. $27.50.

Technique of Organic Chemistry, vol. X, *Fundamentals of Chromatography.* Harold G. Cassidy. Interscience, New York, 1957. 464 pp. $9.75.

The Copernican Revolution. Planetary astronomy in the development of Western thought. Thomas S. Kuhn. Harvard University Press, Cambridge, Mass., 1957. 315 pp. $5.50.

The Chemistry of Organometallic Compounds. Eugene G. Rochow, Dallas T. Hurd, Richard N. Lewis. Wiley, New York; Chapman & Hall, London, 1957. 350 pp. $8.50.

Marine Algae of the Northeastern Coast of North America. William Randolph Taylor. University of Michigan Press, Ann Arbor, rev. ed., 1957. 517 pp. $12.50.

Scientific German. A concise description of the structural elements of scientific and technical German. George E. Condoyannis. Wiley, New York; Chapman & Hall, London, 1957. 171 pp. $2.50.

Scientific French. A concise description of the struc-

tural elements of scientific and technical French. William N. Locke. Wiley, New York; Chapman & Hall, London, 1957. 122 pp. $2.25.

The Infectious Diseases of Domestic Animals. With special reference to etiology, diagnosis, and biologic therapy. William A. Hagan and Dorsey W. Bruner. Comstock Div., Cornell University Press, Ithaca, N.Y., ed. 3, 1957. 988 pp. $10.50.

Mathematics and Statistics for Use in Pharmacy, Biology and Chemistry. L. Saunders and R. Fleming. Published under the direction of the Council of The Pharmaceutical Society of Great Britain. Pharmaceutical Press, London, 1957. 267 pp. 27s. 6d.

Applied Probability. vol. VII of *Proceedings of Symposia in Applied Mathematics*, McGraw-Hill (for American Mathematical Society), New York, 1957. 109 pp. $5.

The Amateur Astronomer. Patrick Moore. Norton, New York, 1957. 351 pp. $4.50.

Chimica Generale e Inorganica. Giuseppe Bruni. Libreria Editrice Politecnica Tamburini, Milan, Italy, ed. 10, 1957. 790 pp.

The Journal of a Scientician. Piero Modigliani. Philosophical Library, New York, 1957. 136 pp. $3.75.

Radioactivity and Nuclear Physics. James M. Cork. Van Nostrand, Princeton, N.J. ed. 3, 1957. 427 pp. $7.75.

College Chemistry. William H. Nebergall and Frederic C. Schmidt. Heath, Boston, 1957. 796 pp. $6.75.

Principles of Microbiology. Charles F. Carter and Alice L. Smith. Mosby, St. Louis, ed. 3, 1957. 665 pp. $5.

Magnetic Removal of Foreign Bodies. The use of the alnico magnet in the recovery of foreign bodies from the air passages, the esophagus, stomach and duodenum. Murdock Equen. Thomas, Springfield, Ill., 1957. 101 pp. $4.50.

General and Applied Entomology. V. A. Little. Harper, New York, 1957. 551 pp. $7.

Psychology, Evolution and Sex. Cecil P. Martin. Thomas, Springfield, Ill., 1957. 179 pp.

Techniques of Guidance. Arthur E. Traxler. Harper, New York, rev. ed., 1957. 387 pp.

A History of Luminescence from the Earliest Times until 1900. Memoir, vol. 44. E. Newton Harvey. American Philosophical Society, Philadelphia, 1957. 705 pp. $6.

The Terpenes, vol. IV, *The Triterpenes and Their Derivatives: Hydrocarbons, Alcohols, Hydroxy-aldehydes, Ketones and Hydroxy-ketones.* The late Sir John Simonsen and W. C. J. Ross. Cambridge University Press, New York, 1957. 533 pp. $13.50.

Annual Review of Plant Physiology, Vol. 8. A. S. Crafts, Leonard Machlis, John G. Torrey. Annual Reviews, Palo Alto, Calif., 1957. 477 pp. $7.

Veterinary Guide for Farmers. G. W. Stamm. Dalls S. Burch, Ed. Windsor, Chicago, Ill., ed. 3, 1957. 384 pp. $3.95.

Black Bourgeoisie. The rise of a new middle class in the United States. E. Franklin Frazier. Free Press, Glencoe, Ill., 1957. 264 pp. $4.

Modern Science and the Nature of Life. William S. Beck. Harcourt, Brace, New York, 1957. 319 pp. $5.75.

Instrumental Analysis. Paul Delahay. Macmillan, New York, 1957. 395 pp. $7.90.

Annuaire des Organisations Internationales. 1956–57. L'Union des Associations Internationales, Brussels, ed. 6, 1957. 1266 pp. $10.

Nuclear Reactors for Research, vol. 3 in *The Geneva Series on the Peaceful Uses of Atomic Energy.* Clifford K. Beck, Ed. Van Nostrand, Princeton, N.J., 1957. 279 pp. $8.50.

Man Against Germs. A. L. Baron. Dutton, New York, 1957. 320 pp. $4.50.

Mathematics, Magic and Mystery. Martin Gardner. Dover, New York, 1956. 188 pp. $1.

The Chemical History of a Candle. Michael Faraday. Reprinted with foreword by E. N. da C. Andrade; biographical introduction by Sir J. Arthur Thomson. Crowell, New York, 1957. 190 pp. $2.75.

Elementary Practical Organic Chemistry. Pt. I, *Small Scale Preparations*, vol. 1 of *Elementary Practical Organic Chemistry*. Arthur I. Vogel. Longmans, Green, New York, 1957. 376 pp. $4.50.

Notions de Cytologie et Histologie. M. Chèvremont. Desoer, Liège, 1956. 998 pp.

Frontiers of Knowledge in the Study of Man. Lynn White, Jr., Ed. Harper, New York, 1956. 342 pp. $4.50.

Jets, Wakes, and Cavities. vol. 2 of *Applied Mathematics and Mechanics*. Garrett Birkhoff and E. H. Zarantonello. Academic Press, New York, 1957. 365 pp. $10.

Tables of the Non-Central t-Distribution. Density function, cumulative distribution function, and percentage points. *Stanford Studies in Mathematics and Statistics*, 1. George J. Resnikoff and Gerald J. Lieberman. Stanford University Press, Calif., 1957. 389 pp. $12.50.

Building an Engineering Career. Clement C. Williams and Erich A. Farber. McGraw-Hill, New York, ed. 3, 1957. 309 pp. $4.75.

The American Oasis. The land and its uses. Edward Higbee, Knopf, New York, 1957. 272 pp. $5.

Muscle Relaxants in Anesthesiology. A monograph in the Bannerstone Division of American Lectures in Anesthesiology. Francis F. Foldes. Thomas, Springfield, Ill.; Blackwell, Oxford, England; Ryerson, Toronto; 1957. 232 pp. $5.50.

The Challenge of Soviet Education. George S. Counts. McGraw-Hill, New York, 1957. 343 pp. $6.

Thermodynamics and Statistical Mechanics. A. H. Wilson. Cambridge University Press, New York, 1957. 510 pp. $9.50.

Life, Language, Law. Essays in honor of Arthur F. Bentley. Richard W. Taylor, Ed. Antioch Press, Yellow Springs, Ohio, 1957. 235 pp. $4.50.

Treatise on Marine Ecology and Paleoecology. vol. 2, *Paleoecology*. Memoir 67. Harry S. Ladd, Ed. Geological Society of America, New York, 1957. 1087 pp. $10.

The Conquest of the Antarctic. Norman Kemp. Philosophical Library, New York, 1957. 152 pp. $4.75.

Comfort for Survival. In nature and man. Angus M. Woodbury. Vantage, New York, ed. 1, 1957. 110 pp. $3.

Living Chemistry. Maurice R. Ahrens, Norris F. Bush, Ray K. Easley. Ginn, Boston, rev. ed. 2, 1957. 638 pp. $5.28.

The Theory of Social Structure. S. F. Wadel. Free Press, Glencoe, Ill., 1957. 175 pp.

Plant Ecology. William Leach. Methuens' Monographs on Biological Subjects. Michael Abercrombie, Ed. Methuen, London; Wiley, New York, ed. 4, 1957. 113 pp. $2.

The Idealist Tradition. From Berkeley to Blanshard. vol. 1 of *The Library of Philosophical Movements*.

Paul Edwards, Ed. Free Press, Glencoe, Ill., 1957. 376 pp. $5.50.

Plant Virus Serology. R. E. F. Matthews. Cambridge University Press, New York, 1957. 139 pp. $5.

The American Annual: 1957. An encyclopedia of the events of 1956. Lavinia P. Dudley and John J. Smith, Eds. Americana Corp., New York, 1957 (order from Americana Corp., 333 N. Michigan Ave., Chicago). 936 pp. $12.

L'Evolution de la Lithosphère: Orogénèse. vol. III (pts. 1 and 2) of *Traité de Géologie*. Henri Termier and Geneviève Termier. Masson, Paris, 1956; 1957. 498 pp.; 437 pp. F. 9800 per volume.

Electricity and Magnetism. J. Newton. Philosophical Library, New York, 1956. 622 pp. $10.

The History of Mathematics. Joseph Ehrenfried Hofmann. Translated from the German by Frank Gaynor and Henrietta O. Midonick. Philosophical Library, New York, 1957. 143 pp. $4.75.

Canadian Cancer Conference. vol. 2. Proceedings of the second Canadian Cancer Research Conference, Honey Harbour, Ont. 17–21 June 1956. R. W. Begg, Ed. Academic Press, New York, 1957. 410 pp. $8.50.

Archaeology in the U.S.S.R. Mikhail Miller. No. 3 of *Research Monographs* of the Research Program on the U.S.S.R. Praeger, New York, 1956. 232 pp. $5.

The Next 50 Billion Years. An astronomer's glimpse into the future. Kenneth Heuer. Viking, New York, ed. 2, 1957. 144 pp. $3.

A Handbook of Hard Metals. W. Dawihl. Abridged English translation of *Handbuch der Hartmetalle*. Philosophical Library, New York, 1956. 170 pp. $10.

Walt Disney: Secrets of Life. A true-life adventure. Rutherford Platt and the staff of the Walt Disney Studio. Based on the film narration by James Algar. Simon and Schuster, New York, 1957. 124 pp. $2.95.

The Wonder of Snow. Corydon Bell. Hill and Wang, New York, 1957. 285 pp. $5.

Introduction to Psychology. Ernest R. Hilgard. Harcourt, Brace, New York, ed. 2, 1957. 668 pp.

Beekmantown Group (Lower Ordovician) of Maryland. William J. Sando. Memoir 68. Geological Society of America, New York, 1957. 161 pp.

Year Book 1955–1956. With administrative reports through 14 Dec. 1956. Carnegie Institution of Washington, 1956. 383 pp. Cloth, $1.50; paper, $1.

Hémostase Spontanée, Plaquettes Sanguines et Parois Vasculaires. Actes du Ier symposium de la Fondation V. Baldacci. J. Roskam, Ed. Istituto di Ricerche V. Baldacci, Pisa, Italy, 1956. 190 pp.

Quantum Mechanics. H. A. Kramers. Translated by D. ter Haar. North-Holland, Amsterdam; Interscience, New York, 1957 (5 chapters of pt. 1 published separately as *The Foundations of Quantum Theory*). 512 pp. $12.50.

The Aleut Dentition. A correlative study of dental characteristics in an Eskimoid people. Coenraad F. A. Moorrees. Harvard University Press, Cambridge, Mass., 1957. 206 pp. $4.50.

Vector Spaces and Matrices. Robert M. Thrall and Leonard Tornheim. Wiley, New York; Chapman & Hall, London, 1957. 330 pp. $6.75.

Elementary Theory of Angular Momentum. M. E. Rose. Wiley, New York; Chapman & Hall, London, 1957. 258 pp. $10.

Chemistry of the Covalent Bond. Leallyn B. Clapp. Freeman, San Francisco, 1957. 698 pp. $7.50.

A Theory of the Consumption Function. National Bureau of Economic Research, No. 63, General Series. Milton Friedman. Princeton University Press, Princeton, N.J., 1957. 259 pp. $4.75.

Health and Medical Care in New York City. A report by the Committee for the Special Research Project in the Health Insurance Plan of Greater New York. Harvard University Press (for the Commonwealth Fund), Cambridge, Mass., 1957. 284 pp. $7.50.

Quality Control and Statistical Methods. Edward M. Schrock. Reinhold, New York; Chapman & Hall, London, ed. 2, 1957. 259 pp. $6.75.

William Harvey. His life and times, his discoveries, his methods. Louis Chauvois. Philosophical Library, New York, 1957. 271 pp. $7.50.

The Theory of Lie Derivatives and Its Applications. Bibliotheca Mathematica, vol. III. Kentaro Yano. North-Holland, Amsterdam; Noordhoff, Groningen; Interscience, New York, 1957. 309 pp. $8.75.

High-Speed Small Craft. Peter Du Cane. Philosophical Library, New York, ed. 2, 1957. 336 pp. $15.

Genetics. Edgar Altenburg. Holt, New York, rev. ed., 1957. 511 pp. $6.50.

Plant and Process Dynamic Characteristics. Proceedings of a conference held at Cambridge 4–6 April 1956 by the Society of Instrument Technology. Academic Press; New York; Butterworths, London, 1957. 258 pp. $8.80.

A Visit to the Hospital. Francine Chase. Grosset & Dunlap, New York, 1957. 68 pp.

The Person in Psychology: Reality or Abstraction. Paul LaFitte. Philosophical Library, New York, 1957. 243 pp. $6.

Glossary of Geology and Related Sciences. J. V. Howell, Coordinating Chairman. American Geological Institute, 2101 Constitution Avenue, NW, Washington, D.C., 1957. 335 pp. $6.

Technical Descriptive Geometry. B. Leighton Wellman. McGraw-Hill, New York, 1957. 540 pp. $5.75.

Modern Applied Photography. G. A. Jones. Philosophical Library, New York, 1957. 168 pp. $4.75.

Limited War: the Challenge to American Strategy. Robert E. Osgood. University of Chicago Press, Chicago, 1957. 326 pp. $5.

Numerical Methods. R. A. Buckingham. Pitman, New York, 1957. 609 pp. $15.

The 1,2,3- and 1,2,4-Triazines, Tetrazines and Pentazines. John G. Erickson, Paul F. Wiley, V. P. Wystrach. Interscience, New York, 1956. 272 pp. $9.50.

Pilot Plants, Models, and Scale-up Methods in Chemical Engineering. Robert E. Johnstone and Meredith W. Thring. McGraw-Hill, New York, 1957. 318 pp. $9.50.

Ion Exchangers in Organic and Biochemistry. Calvin Calmon and T. R. E. Kressman. Interscience, New York, 1957. 773 pp. $15.

Language and Religion. A semantic preface to a philosophy of religion. Ben F. Kimpel. Philosophical Library, New York, 1957. 153 pp. $3.75.

An Essay on Mankind. Gerhard Hirschfeld. Philosophical Library, New York, 1957. 114 pp. $3.75.

Chimie Organique Générale. Jean Vène. Masson, Paris, 1957. 349 pp. Paper, F. 3500; cloth, F. 4100.

La Chimie Nucléaire et Ses Applications. M. Haïssinsky. Masson, Paris, 1957. 651 pp. Paper, F. 5000; cloth, F. 5600.

College Physics. Robert T. Beyer and A. O. Williams, Jr. Prentice-Hall, Englewood Cliffs, N.J., 1957. 671 pp. $7.50.

New OXFORD Scientific Texts and Monographs

Contact Catalysis
Third Edition

By R. H. GRIFFITH. This is a rewritten third edition of *The Mechanism of Contact Catalysis*, published in 1946 and out of print since 1954. It accounts for ten years of great activity in the theoretical and experimental study of heterogeneous catalysts, including such important subjects as the physics of the solid state and of gas-solid systems, the significance of the electronic factor in catalysis, and hydrocarbon reactions. $8.00

Electricity and Magnetism

By BETTY ISABELLE BLEANEY and BREBIS BLEANEY. A comprehensive textbook giving an up-to-date account of the theory and experimental aspects of electricity and magnetism. Principal subjects included are: electrostatics, electric currents and magnetic fields, magnetostatics and magnetic effects; alternating current theory and electromagnetic waves, including filters, transmission lines and wave guides; electromagnetic machinery and thermionic vacuum tubes, a.c. measurements in the various frequency bands, etc. $10.10

Theories of Nuclear Moments

By ROGER JOHN BLIN-STOYLE. The first of a new series of monographs at the post-graduate level on physics and related subjects, ranging from 30,000 to 40,000 words in length. This volume is a comparison of facts learned in the laboratory with theoretical predictions on the electromagnetic moments of the nucleus, most of which have been based on a simplified model of the nucleus. The modifying effects of any meson currents which may occur are also considered in detail. $1.40

The Detection and Measurement of Infra-Red Radiation

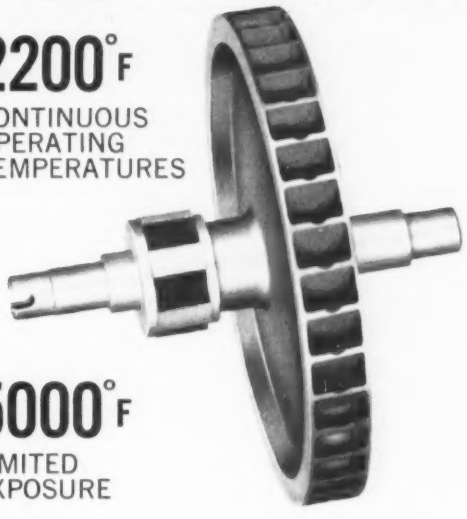
By R. A. SMITH, F. E. JONES and R. P. CHASMAR. This comprehensive account of recent developments deals with the properties of thermal detectors such as thermo-piles and bolometers and discusses their limitations. It accounts for modern photoconductive detectors which use the lead salts PbS, PbTe, PbSe, and fully treats the random fluctuations which limit the sensitivity of all forms of detectors. $11.20

At all bookstores

OXFORD UNIVERSITY PRESS, Inc.
114 Fifth Avenue, New York 11

KENTANIUM*

2200°F
CONTINUOUS OPERATING TEMPERATURES



5000°F
LIMITED EXPOSURE

If any of your designs are grounded because your temperatures are too high for your materials—Kentanium may be just what you need.

Kentanium is the name of a family of Titanium Carbides, developed by Kennametal Inc. It is molded from powders into many forms, retains strength and structural integrity at elevated temperatures, and possesses unusual resistance to thermal shock.

Engineers have reported successful use at continuous operating temperatures up to 2200°F, and under intermittent exposures up to 5000°F, where oxidizing atmospheres were combined with abrasion, and the parts were under compressive or tensile loading.

Many grades of this lightweight, exceptionally pure titanium carbide have been developed for various requirements. Kentanium can be extruded and molded into many forms, eliminating difficult machining. More intricate forms are readily machined from pressed slugs. Precise dimensional tolerances are attained by grinding after forms are sintered.

Kentanium is presently serving in bearings, thrust runners and other parts in pumps for handling high temperature liquid metals; blades, wheels, nozzle vanes, and temperature sensing elements for gas turbines and jet engines; bushings, seals and bearings (unlubricated); and other applications at high temperatures. Added information is offered in our bulletin "Kentanium." Send for it . . . and ask Kennametal engineers for added help if you need it to adapt Kentanium to your specific problem. Write KENNAMETAL INC., Dept. MS, Latrobe, Pennsylvania.

*Kentanium and Kennametal are the trademarks of a series of hard carbide alloys of tungsten, tungsten-titanium and tantalum.

C-3078

INDUSTRY AND **KENNAMETAL**
...Partners in Progress

Meetings

September

10–13. Biometric Soc., Eastern North American Region, Atlantic City, N.J. (A. M. Dutton, Box 287, Sta. 3, Rochester, N.Y.)

10–13. Econometric Soc., Atlantic City, N.J. (R. Ruggles, Dept. of Economics, Yale University, New Haven, Conn.)

10–13. Institute of Mathematical Statistics, annual, Atlantic City, N.J. (G. E. Nicholson, Jr., Dept. of Statistics, Univ. of North Carolina, Chapel Hill.)

14–15. Minnesota Acad. of Science, Cedar Creek Forest. (M. R. Boudrye, 51 University Ave., St. Paul 3, Minn.)

15–18. American Inst. of Chemical Engineers, national, Baltimore, Md. (F. J. Van Antwerpen, AIChE, 25 W. 45 St., New York 36.)

18–20. Formation and Stabilization of Free Radicals, symp., Washington, D.C. (A. M. Bass, Free Radicals Research Section, National Bureau of Standards, Washington 25.)

18–21. Child Psychology Symp., Worcester, Mass. (D. Evans, News Bureau, Clark Univ., Worcester.)

18–21. International Mineral Dressing Cong., Stockholm, Sweden. (J. Hedlund, IMDC, Näckströmsgatan 1^{III}, Stockholm C.)

19–21. Office Dermatology, postgraduate conf., San Francisco, Calif. (Office of the Dean, Stanford Univ. School of Medicine, 2398 Sacramento St., San Francisco 15.)

22–28. Mesons and Recently Discovered Particles, colloquium, IUPAP, Venice, Italy. (A. Rostagni, Istituto di Fisica dell' Universita, Via Marzolo 8, Padua, Italy.)

23–24. Fluid Flow in Porous Media, conf., Norman, Okla. (C. G. Dodd, Petroleum Engineering Dept., Univ. of Oklahoma, Norman.)

23–25. American Soc. of Mechanical Engineers, fall, Hartford, Conn. (C. E. Davies, ASME, 29 W. 39 St., New York 18.)

23–27. International Soc. of Bioclimatology and Biometeorology, Vienna, Austria. (S. W. Tromp, Hofbrouckerlaan 54, Oegstgeest-Leiden, Holland.)

24–25. Industrial Electronics Conf., Chicago, Ill. (E. A. Roberts, Union Thermoelectric Corp., 2001 Greenleaf St., Evanston, Ill.)

25–27. Mississippi Valley Medical Soc., annual, St. Louis, Mo. (H. Swanberg, 510 Maine St., Quincy, Ill.)

28–30. American College of Hospital Administrators, 23rd annual, Atlantic City, N.J. (D. Conley, ACHA, 620 N. Michigan Ave., Chicago 11, Ill.)

29–5. World Medical Assoc., Istanbul, Turkey. (L. H. Bauer, 10 Columbus Circle, New York 19.)

30–2. American Oil Chemists' Soc., fall, Cincinnati, O. (Miss L. R. Hawkins, AOCS, 35 E. Wacker Dr., Chicago 1, Ill.)

30–8. International Council for the Exploration of the Sea, 45th annual, Bergen, Norway. (A. Fridriksson, ICES, Charlottenlund Slot, Charlottenlund, Denmark.)

October

1–4. American Roentgen Ray Soc., annual, Washington, D.C. (B. R. Young, Germantown Hospital, Philadelphia 44, Pa.)

2–4. American Soc. of Photogrammetry, semiannual, St. Louis, Mo. (C. E. Palmer, ASP, 1515 Massachusetts Ave., NW, Washington 5.)

2–4. Antibiotics, 5th annual symp., Washington, D.C. (H. Welch, Div. of Antibiotics, Food and Drug Administration, U.S. Dept. of Health, Education, and Welfare, Washington 25.)

4. Role of Agriculture in Future Society, 75th anniversary symp., Geneva, N.Y. (New York State Agricultural Experiment Station, Cornell Univ., Geneva.)

4–6. Indiana Geologic Field Conf., 9th, Mitchell, Ind. (H. H. Gray, Indiana Field Conf., Dept. of Conservation, Geological Survey, Bloomington, Ind.)

6–10. Electrochemical Soc., fall, Buffalo, N.Y. (H. B. Linford, 1860 Broadway, New York 23.)

7–9. National Electronics Conf., Chicago, Ill. (J. S. Powers, NEC, 84 E. Randolph St., Chicago 1.)

7–11. American Inst. of Electrical Engineers, fall general, Chicago, Ill. (N. S. Hibshman, AIEE, 33 W. 39 St., New York 18.)

7–11. Research Contributions to Clinical Practice, New York Acad. of Medicine Postgraduate Week, New York. (Secretary, Postgraduate Week, New York Acad. of Medicine, 2 E. 103 St., New York 29.)

8–10. International Assoc. of Milk and Food Sanitarians, annual, Louisville, Ky. (H. H. Wilkowske, Dairy Science Dept., Univ. of Florida, Gainesville.)

8–10. Upper Air Conf., American Meteorological Soc., Omaha, Nebr. (K. C. Spengler, AMS, 3 Joy St., Boston 8, Mass.)

9–11. High Vacuum Technology, 4th annual symp., Boston, Mass. (Committee on Vacuum Techniques, P.O. Box 1282, Boston 9.)

9–11. Society for Experimental Stress Analysis, fall, San Diego, Calif. (W. M. Murray, SESA, P.O. Box 168, Cambridge 39, Mass.)

9–12. Tau Beta Pi Assoc., annual, Madison and Milwaukee, Wis. (R. H. Nagel, Univ. of Tennessee, Knoxville.)

10–11. Noise Abatement Symp., 8th annual, Chicago, Ill. (J. J. Kowal, Armour Research Foundation, 10 W. 35 St., Chicago 16.)

13–18. American Acad. of Ophthalmology and Otolaryngology, annual, Chicago, Ill. (W. L. Benedict, 100 First Avenue Bldg., Rochester, Minn.)

14–16. Association of Official Agricultural Chemists, annual, Washington, D.C. (W. Horwitz, Box 540, Benjamin Franklin Station, Washington 4.)

14–18. American College of Surgeons, 43rd annual clinical cong., Atlantic City, N.J. (ACS, 40 E. Erie St., Chicago 11, Ill.)

14–18. American Soc. of Civil Engineers, New York, N.Y. (W. H. Wisely, ASCE, 33 W. 39 St., New York 18.)

14–18. International Industrial Development Conf., San Francisco, Calif. (E. S. Prentice, Stanford Research Inst., Menlo Park, Calif.)

16–23. Enzyme Chemistry, internatl. symp., Tokyo and Kyoto, Japan. (International Symp. on Enzyme Chemistry, Science Council of Japan, Ueno Park, Tokyo.)

17–18. American Ceramic Soc., 10th Pacific Coast mtg., San Francisco, Calif. (C. S. Pearce, ACS, 4055 N. High St., Columbus 14, Ohio.)

17–18. Industrial Hydraulics, natl. conf., Chicago, Ill. (Conference Secretary, Armour Research Foundation, 10 W. 35 St., Chicago 16.)

17–19. Indiana Acad. of Science, Greencastle. (H. Crull,

(*Continued on page viii*)

MISSILE SYSTEMS ELECTRONICS

Major achievement is required in the following fields:

Control systems, inertial guidance, information processing systems, electronic product engineering, radar systems, antennas, circuit design, logical design, microwave devices, communication theory, electromagnetic wave propagation, infrared systems, telemetering systems.

Inquiries are invited. Please address the Research and Development Staff, Palo Alto 34, California.

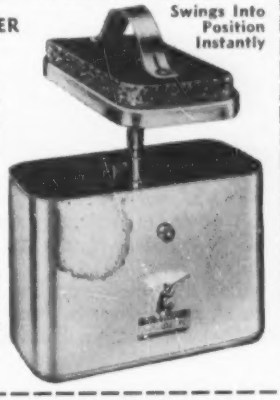
Lockheed **MISSILE SYSTEMS**

A DIVISION OF
LOCKHEED AIRCRAFT CORPORATION
PALO ALTO • SUNNYVALE • VAN NUYS
CALIFORNIA

Swivel-Seat SHELL BOX

MAKES YOU A BETTER DUCK HUNTER

Swings Into Position Instantly



Swings into any position wanted instantly for a better shot. It's compact, and the new rounded design fits your boat comfortably and it's easy to carry. Built to duck hunters' specifications.

Holds 6 to 8 boxes of shells. Made of heavy gauge steel. All joints seam-welded. Positively watertight and rust-proof. Size closed 13" x 6" x 10". Finished in non-reflecting, dull finish olive green baked enamel. Heavy leather handle for easy carrying which lies flat when used as a seat. Price $9.98

AMAZING BLOCK & TACKLE

- PORTABLE . . . weighs only 13 ozs., fits in pocket!
- ONE HAND OPERATION . . .
- POWERFUL . . . lifts up to 1000 lbs.!

Amazing Work Saver For

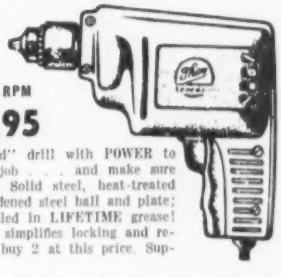
- Hunters
- Farmers
- Yachtsmen
- Handymen
- Truck drivers
- Motorists

Here's an unusual tool, even for us! It's the tiny Midget Babe Block and Tackle. It weighs only 13 oz., yet is so powerful it lifts up to 1000 lbs. easily! Because of its great strength, small size, complete portability—this block and tackle has many uses. In your car for emergencies, for home, factory, farm . . . for loading heavy articles. For sportsmen: loading deer, boats, etc. For anyone who has to do heavy lifting! Fine engineered throughout, best grade aluminum, steel axles, pre-lubricated for life. Hoists have two lifting slongs, at top and bottom, with heavy welded steel rings. Slings can be doubled for extra strength. Complete with 70 ft. nylon cord, 5 to 1 ratio— 1000 lb. test. Carrying bag. Instructions ..... ppd. $9.95

ALSO AVAILABLE—Tiny Babe—Lifts up to 2000 lbs.! With 100 ft. nylon cord, 5-1 ratio—2000 lb. test—15 oz. wgt. Twice as powerful as $9.95 model—only $12.95 ppd.

1 yr. guarantee on both models.

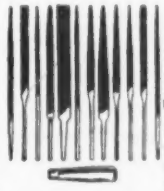
2½ AMP. HEAVY DUTY ¼" THOR SPEEDRILL



with Geared Chuck AC-DC 2400 RPM
Reg. $39.95
OUR PRICE **$14.95**
plus 50¢ pp. and hdg.

If your work calls for a "rugged" drill with POWER to SPARE, insist on a 2½ Amp. job . . . and make sure it's THOR! No finer drill made. Solid steel, heat-treated helical gears; thrust taken on hardened steel ball and plate; gears permanently packed and sealed in LIFETIME grease! Switch, trigger and lock assembly simplifies locking and releasing trigger. You'll be wise to buy 2 at this price. Supplies limited!.....

12 Pc. Needle & Warding FILE SET



ONLY $2.49
(plus 25¢ hdg. & pstg.) 25¢ ppd. & hdg.

Made from the best quality tool steel, to fit the exacting requirements of mechanics, watch and jewelry craftsmen, hobbyists. Attractive kit contains the following 5½" long needle and warding files with high test cutting qualities: round, flat, knife, square, triangular. In all textures: fine, medium fine, medium, medium coarse, coarse. Comes with polished wood handle and new type steel grip chuck.

Send Check or M.O. C.O.D. plus fee. Money Back Guarantee.

SCOTT-MITCHELL HOUSE, INC.
DEPT. 7109, 611 Broadway, New York 12, N.Y.

C14 BIO-CHEMICAL TRACERS!

- AMINO ACIDS
- PURINES
- INTERMEDIATES
- KREBS CYCLE COMPOUNDS
- STEROIDS

Labeled with H^3, H^3, C^{14}, P^{32}, I^{131}, Etc.

For Detailed Information Regarding Tracers and/or Counting Equipment

WRITE OFFICE NEAREST YOU—

manufactured by

ISOTOPES SPECIALTIES COMPANY INC.

nucor

A Subsidiary of Nuclear Corporation of America, Inc.

WESTERN SALES
Isotopes Specialties
703 South Main Street
Burbank, California

MID-AMERICA SALES
Nuclear Corp.
9842 Manchester Road
St. Louis 19, Missouri

EASTERN SALES
Nuclear Corp.
33-61 Crescent Street
Long Island City 6, N.Y.

(*Continued from page vi*)

Dept. of Mathematics, Butler Univ., Indianapolis 7, Ind.)

17–19. Optical Soc. of America, Columbus, Ohio. (S. S. Ballard, Visibility Lab., Scripps Institution of Oceanography, San Diego 52, Calif.)

18–19. National Soc. of Professional Engineers, Bismarck, N.D. (P. H. Robbins, 2029 K St., NW, Washington 6, D.C.)

19–26. Social Work, 3rd Pan American cong., San Juan, Puerto Rico. (A. P. Dorla, Apartado 3271, San Juan.)

20–22. American College of Apothecaries, St. Louis, Mo. (R. E. Abrams, Hamilton Ct., Chestnut and 39 St., Philadelphia, Pa.)

21. Air Pollution Symp., 2nd annual, Philadelphia, Pa. (A. D. Hollingsworth, Franklin Inst., Benjamin Franklin Parkway at 20th, Philadelphia 3.)

21–25. Medical Aspects of Workmen's Compensation, New York. (Office of Associate Dean, New York Univ. Post-Graduate Medical School, 550 First Ave., New York 16.)

21–26. Ultra High Frequency Circuits and Antennas, internatl. conf., Paris, France. (Congrès Circuits et Antennes Hyperfréquences, Société des Radioélectriciens, 10, Avenue Pierre-Larousse, Malakoff (Seine) France.)

22. American Soc. of Safety Engineers, annual, Chicago, Ill. (J. B. Johnson, ASSE, 425 N. Michigan Ave., Chicago 11.)

22–25. American Dietetic Assoc., annual, Miami, Fla. (Miss R. M. Yakel, ADA, 620 N. Michigan Ave., Chicago 11, Ill.)

24–25. Computer Applications Symp., Chicago, Ill. (Conference Secretary, Armour Research Foundation, 10 W. 35 St., Chicago 16.)

24–25. New Mexico Acad. of Science, annual, Albuquerque. (W. J. Koster, Dept. of Biology, Univ. of New Mexico, Albuquerque.)

24–26. Acoustical Soc. of America, Ann Arbor, Mich. (W. Waterfall, ASA, 57 E. 55 St., New York 22.)

24–5. Pan Indian Ocean Science Assoc., 3rd cong., Tananarive, Madagascar. (R. Paulian, Institut de Recherche Scientifique, B.P. 434, Tananarive.)

25–26. Kentucky Acad. of Science, Berea, Ky. (G. Levey, Berea College, Berea.)

25–28. American Heart Assoc. Scientific Sessions, Chicago, Ill. (Medical Director, AHA, 44 E. 23 St., New York 10.)

26. American Mathematical Soc., Washington, D.C. (J. H. Curtiss, AMS, 190 Hope St., Providence 6, R.I.)

27–1. Atom Fair, New York, N.Y. (Atomic Industrial Forum, 3 E. 54 St., New York 22.)

28–30. Association of Military Surgeons of the U.S., annual, Washington, D.C. (R. E. Bitner, AMSUS, Suite 718, 1726 Eye St., Washington 6.)

28–31. American Nuclear Soc., 2nd winter, New York, N.Y. (J. Burt, J. M. Mathes, Inc., 260 Madison Ave., New York 16.)

29–31. Entomological Soc. of Canada, annual, Lethbridge, Alta., Canada. (R. H. Wigmore, Science Service Bldg., Carling Ave., Ottawa 3, Ont.)

29–3. Photoperiodism in Plants and Animals, internatl. conf., Gatlinburg, Tenn. (R. Winthrow, Div. of Radiation and Organisms, Smithsonian Institution, Washington 25.)

30–2. American Soc. of Parasitologists, annual, Philadelphia, Pa. (P. E. Thompson, Research Div., Parke, Davis & Co., Detroit 32, Mich.)

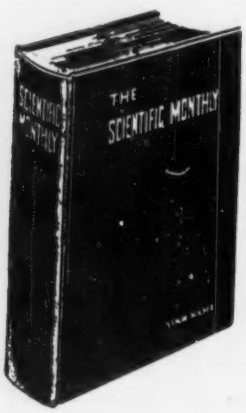
30–2. American Soc. of Tropical Medicine and Hygiene, annual, Philadelphia, Pa. (R. B. Hill, 3575 St. Gaudens Rd., Miami 33, Fla.)

30–2. Federation of Paint and Varnish Production Clubs, 35th annual, Philadelphia, Pa. (FPVPC, 121 S. Broad St., Philadelphia 7.)

31. Reactor Safety Conf., New York, N.Y. (Atomic Industrial Forum, 3 E. 54 St., New York 22.)

31–2. Engineering and Scientific Education Conf., Chicago, Ill. (J. E. Harrington, Western Soc. of Engineers, 84 E. Randolph St., Chicago 1.)

31–2. Gerontological Soc., annual, Cleveland, Ohio. (N. W. Shock, Baltimore City Hospitals, Baltimore 24, Md.)



Preserve your SM copies for quick, easy reference with attractive

<< BINDERS

$3 each; add 50¢ postage for orders outside U.S.A. (Name, 75¢ extra; year, 50¢ extra.) Personal check or money order, please!

The SCIENTIFIC MONTHLY 1515 Mass. Ave., NW Washington 5, D. C.

TO AUTHORS
seeking a publisher

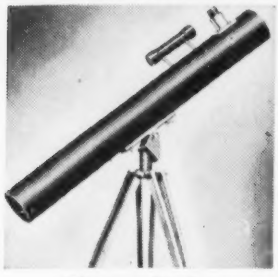
Learn how we can publish, promote and distribute your book on a professional, dignified basis. All subjects considered. Scholarly and scientific works a specialty. Many successes, one a best seller. Write for booklet SM—it's free.

VANTAGE PRESS, Inc. • 120 W. 31 St., N.Y. 1
In Calif.: 6253 Hollywood Blvd., Hollywood 28
In Wash., D.C.: 1010 Vermont Ave., NW

QUALITY SERVICE
SWISS WEBSTER MICE
BELLEWOOD FARM
ENGLISHTOWN, N.J. Phone 7-1438

SENSATIONAL OPTICAL BARGAINS

See the Stars, Moon, Planets Close Up!
3" ASTRONOMICAL REFLECTING TELESCOPE



Famous Mt. Palomar Type!

60 & 120 Power
An Unusual Buy!

Assembled - Ready to Use!

You'll see the Rings of Saturn, the fascinating planet Mars, huge craters on the Moon, Star Clusters, Moons of Jupiter in detail, Galaxies! Non - breakable aluminum covered tube. Equatorial mount with lock on both axes. Aluminized and overcoated 3" diameter high-speed f/10 ventilated mirror. Telescope comes equipped with a 60X eyepiece and a mounted Barlow Lens, giving you 60 and 120 power. An Optical Finder Telescope, always so essential, is also included. Sturdy, hardwood, portable tripod.

Free with scope: Valuable STAR CHART and 272 page "Astronomy Book".

Stock No. 85,050-X
$29.50 f.o.b. Barrington, N. J.
(Shipping wt. 10 lbs.)

Photographers!

Adapt your camera to this Scope for excellent Telephoto shots and fascinating photos of moon! Shown below is an actual photograph of the moon taken through our Astronomical Telescope by a 17 year-old student.

A "CLOSE-OUT" BARGAIN SPECIAL
7 x 50 MONOCULAR

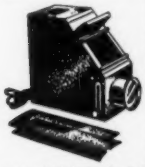
This is fine quality, American made instrument—war surplus! Actually ½ of U. S. Govt. 7 x 50 Binocular. Used for general observation both day and night . . . to take fascinating telephoto shots. Brand new. 095 value. Due to Japanese competition we close these out at a bargain price. Directions and mounting Hints included.

Stock No. 50,003-X ..... 715.00 Pstpd.

BUILD A SOLAR ENERGY FURNACE
Great Project for Geophysical Year!

A fascinating new field. You can build your own Solar Furnace for experimentation—many practical uses. It's easy—inexpensive, use your scrap wood. We furnish instruction sheet. This sun powered furnace will generate terrific heat—2000° to 3000°. Fuses enamel to metal. Produces many unusual fusing effects. Sets paper aflame in seconds. Use our Fresnel Lens—14¾" diameter . . . f.l. 14".

Stock No. 70,130-X package of 1 ..... $6.00 Postpaid
Stock No. 70,131-X package of 2 ..... 11.00 Postpaid
Stock No. 70,132-X package of 4 ..... 20.00 Postpaid



OPAQUE PROJECTOR—WAR SURPLUS

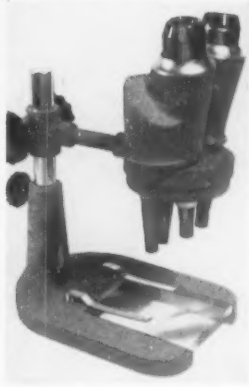
Made by Beseler for the Navy—Model OA. New complete with 300-watt, 115-volt bulb, projection lens and copy holders. About a $40.00 value. Use 8 to 15 feet from screen to get 2½ and 5 feet square pictures. Copy can be held front of projector and projector is furnished with a copy carrier for pictures you paste on 5 x 8 inch file cards and on 2½ x 3½" cards. Children love these. They can project their art work, comic books, school pictures, snapshots, colored pictures in full color, etc.

Stock No. 85,048-X (Shipping weight 14 lbs.)
$20.00 F.O.B. Barrington, N. J.

VARIABLE DENSITY GOGGLES—WAR SURPLUS

A 0 Polaroid. Headband to hold onto your head. Have soft rubber mounting in contact with your face. Small knob in front to rotate Polaroid filters to vary the density of light reaching your eyes. You can take apart and get four Polaroid glass mounted filters—1-3/16" diameter. Terrific value! Packed in small tin chest.

Stock No. 50,144-X ..... $2.50 postpaid



Fine, American-Made Instrument at Over 50% Saving

STEREO MICROSCOPE

Up to 3" Working Distance — Erect Image — Wide 3 Dimensional Field

Now, ready after years in development—this instrument answers the long standing need for a sturdy, efficient STEREO MICROSCOPE at low cost. Used in production—in research—in the lab, shop, factory, or at home; for inspections, examinations, counting, checking, assembling, dissecting—speeding up and improving quality control. 2 sets of objectives on rotating turret. Standard pair of wide field 10X Kellner Eyepieces give you 23 power and 40 power. Additional eyepieces available for greater or lesser magnification. A low reflection coated prism erecting system gives you an erect image—correct as to right and left—clear and sharp. Helical rack and pinion focusing. Precision, American-made! Storage chest included. 10-DAY TRIAL . . . complete satisfaction or your money back.

Order Stock No. 85,039-X (Shipping wt. approx. 11 lbs.)

Full price ..... $99.50 f.o.b. Barrington, N. J.
Send Check or M.O.

INFRARED SNIPERSCOPE TELESCOPE & PARTS

See in the dark—without being observed. War surplus Sniperscope M-2. Gov't. cost about $500.00. Used for industrial plant security; research lab experiments; infrared photography; spectroscopy, etc. Instrument complete, ready to use. Includes Power Pack, infrared light source. Will operate from 6 V auto battery. You must furnish battery or transformer.

Stock No. 85,053-X ..... $150.00 f.o.b. Barrington, N.J.
Shpg. Wt. approx. 12 lbs.

Save still more money! Build your own Sniperscope! We will furnish instructions—parts, including: Power Packs, 1P25A image tubes, light units, filters, etc. For details—request FREE Bulletin A-26-X.

SILICONE POLISHING and CLEANING CLOTHS

New! Combines the miracle of Silicones with a non-woven, all rayon cloth. Used over and over (washable) to dust, polish, protect, anti-fog: mirrors, reflectors, lenses, coated optics, crystal glass, lucite, other plastics. Won't scratch. Lintless, non-oily. Cloth size 18x16".

Stock No. 60,059-X . Package of 3 cloths ... $1.00 Pstpd.
Stock No. 70,137-X . Package of 100 cloths . 26.50 Pstpd.
Lower prices on larger quantities

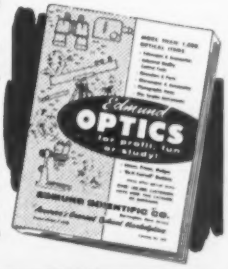
SIMPLE LENS KITS! Fun for adults! Fun for children! Kits include plainly written, illustrated booklet showing how you can build lots of optical items.

Stock No. 5-X—45 lenses $ 5.00 Postpaid
Stock No. 2-X—10 lenses $ 1.00 Postpaid
Stock No. 10-X—80 lenses $10.00 Postpaid

GET OUR GIANT FREE CATALOG-X

Over 1000 Optical Bargains
64 Fascinating Pages

Huge selection of lenses, prisms, war surplus optical instruments, parts and accessories. Telescopes, microscopes, binoculars. Hand spectroscopes, reticles, mirrors, Ronchi rulings, dozens of other hard-to-get optical items. America's No. 1 source of supply for Researchers, Lab. Technicians, Photographers, Hobbyists, Telescope Makers, etc. Ask for catalog X.



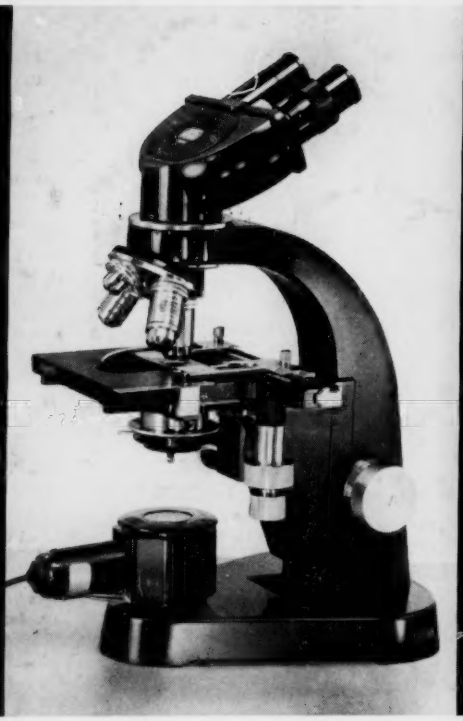
ORDER BY STOCK NUMBER . SEND CHECK OR MONEY ORDER . SATISFACTION GUARANTEED!

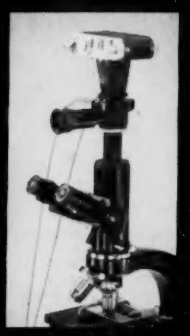
EDMUND SCIENTIFIC CO., BARRINGTON, NEW JERSEY

A NEW CONCEPT IN MICROSCOPE PERFORMANCE

Leitz LABOLUX

LABOLUX S 47/92-15 inclined binocular microscope, with built-in mechanical stage #47, Abbe condenser; quadruple nosepiece with achromats 3.5x, 10x, 45x and 100x oil immersion, the last two having spring-loaded mounts; paired 6x and 10x binocular eyepieces; with carrying case $696.50





LABOLUX for photomicrography with LEICA.

Combined binocular-monocular tube.

The Leitz LABOLUX medical and laboratory microscope is a scientifically engineered instrument of modern design, built for a lifetime of use. The LABOLUX is a new concept in fatigue-free operation and precision performance. It combines the coarse and fine focusing adjustments in a single control; with all controls, including the actuating knob for the mechanical stage, in a low convenient position. High power lenses have spring-loaded mounts preventing damage to lenses or slides.

The LABOLUX can be faced away from the observer, for increased accessibility to all controls and to the object stage. Interchangeable body tubes permit binocular or monocular observation as well as photomicrography, with simultaneous observation and photography made possible through a unique trinocular attachment. A wide variety of accessories makes the Leitz LABOLUX the ideal instrument for hospital or office laboratory.

E. LEITZ, INC., DEPT. SM-9
468 Fourth Ave., New York 16, N.Y.

Please send me the Leitz LABOLUX brochure

Name_____

Street_____

City_____ Zone_____ State_____

Leitz

FIRST IN PRECISION OPTICS

20957

E. LEITZ, INC., 468 FOURTH AVENUE, NEW YORK 16, N.Y.
Distributors of the world-famous products of Ernst Leitz G.m.b.H., Wetzlar, Germany—Ernst Leitz Canada Ltd.
LEICA CAMERAS · LENSES · MICROSCOPES · BINOCULARS